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The Re-grading of Seattle, Washington.

Municipal improvements in this country have of necessity generally been made to meet immediate conditions, with provisions in the design and construction of these works calculated to foresee future development. Except in the largest cities little has been done outside of what may rightfully be called betterments for every-day requirements and park systems. The tremendous rapid rate of growth of the great centers of population and the consequently limited funds available has made such methods imperatively necessary. In many cases these circumstances have caused the delay or complete abandonment of general improvements of more vital importance to the future of the community than to its present development, even where these improvements could be made prior to the congestion of the area benefited at a cost inconsiderable as compared with that involved when they are undertaken later. Such a state of affairs has been so much more prevalent in most Western cities, due to various other additional causes as well, that the re-grading of Seattle described in this and previous issues of The Engineering Record is of more than ordinary import.

The site of Seattle is in general most admirably situated as a port for Oriental and Alaskan ocean traffic and also as a terminal for great transcontinental railway systems; two of the latter have, in fact, long been operating into it and three more are being extended to it. The topography of the site was naturally, however, in no way suited to the location of a large city such as Seattle is apparently destined to become, although it was typical of the eastern shore of Puget Sound. Moreover, the entire surrounding country is rough and broken. That shore of the sound is a series of immense terminal moraines, generally parallel with the shore line and having steep slopes. The city was started on the Sound side of one of these moraines, over which it spread into the valleys and hills beyond. The business section, occupying the original part of the city, was hemmed in at the north and in the rear by high hills, with abrupt slopes reaching almost to the edge of the water, while a great area of low land, submerged by the tide, presented an apparently insurmountable limitation to extension southward.

No attempt to remove these limitations was made until the city had reached such proportions as to render exceedingly expensive the changes necessary to accomplish results of more than immediate consequence. When the enormity of the undertaking required to alter the site according to a general plan that would provide for the proper development of the metropolitan district of which the present business section of Seattle will doubtless be the center, became evident, that plan appeared impossible of execution. But the outcome of the initial work proved so beneficial that little opposition was offered to the prosecution of the succeeding steps, and now the accomplishment of the entire work appears certain.

The general plan that is being followed is described in detail in the article to which reference has been made. Briefly, it consists in cutting down the hills and utilizing the material thus obtained to reclaim the tide flats and to fill valleys between the hills, although a considerable percentage of this material has been most economically wasted in the sound. Following along this line the limitations to the central business district are being removed by the construction of streets on low grades, and by the reclamation of the great adjacent area of low land for railroad terminals and a wholesale and manufacturing district. As a part of the whole scheme a system of diagonal highways is being provided to effect an entrance to the central business district for outlying sections at present practically inaccessible.

Hydraulic sluicing methods have been used to particular advantage in handling a large part of the grading work that has been completed, and are being employed on most of that now under way. Indeed, it is believed that these methods have never been utilized in more extensive work, except perhaps in placer mining. The materials in the hills are such that most of them yield to the streams from hydraulic giants with comparative ease, although much indurated clay has been loosened and moved in this manner. The spoil from the hydraulic operations is also readily transported by the water to the final position it is to occupy. On the other hand, where these methods are employed the entire area must be cut away, requiring the destruction or removal in advance of the existing improvements. While a very great damage is unavoidably incurred in this manner, the property concerned has almost without exception been so greatly enhanced by the grading as to much more than offset the first damage.

The entire plan approaches the ideal and is at once a bold one, such as might be expected to be evolved in a Western community where unusual works must be undertaken to conquer the country. Nevertheless, it is so perfectly feasible and has been demonstrated to be of such tremendous immediate, as well as future value to the city that the advisability of executing it can scarcely be questioned. In fact, it is considered evident that the growth of the city that has already attained would have been greatly hampered in case this work had not been done, if this growth would have occurred in any such proportion, without considering the great future benefit to be obtained.

The Maintenance and Operation of Second-Hand Equipment.

In view of the fact that second-hand equipment is usually purchased for duty in engineering systems more as a temporary expedient than in accord with a carefully designed plan of operation, less attention is in most cases paid to its behavior in service on the cost side than is accorded to new apparatus. There are some instances now and then where the lack of funds in an enterprise at the start necessitates the design of the work with the use of second-hand apparatus in view, but it is a fair assumption that in general such machinery is bought either to supply a sudden demand for increased capacity which cannot be met by the delivery promised on more modern equipment or because in the peculiar circumstances of the problem the saving in first cost is attractive enough to justify the possible operation of the second-hand outfit at a lower efficiency or capacity than can be enjoyed by the use of the most advanced designs on the market.

It doubtless does not pay to spend very much time in the analysis of the performance of second-hand machinery, but in putting such equipment into service it is a mistake to fail to keep any special watch whatever of its running costs, and particularly its repairs. The second-hand machine is a factor in the production economy of the installation as a whole. This entitles it to at least a separation of its maintenance records from those of the rest of the units in the plant, and to as much anticipation of its probable needs in service as good administration can supply. Thus, the same care should be taken to keep extra parts on hand, the best quality of lubricants should not be denied, inspection should be as regular and thorough as in the case of new apparatus, and the occurrence of any frequent failure in parts that may be weakened or any excessive renewal charges in a single item ought to be handled by the maintenance department as conscientiously as though some untried piece of machinery were at issue as to its fitness for the service.

Tests of second-hand apparatus seldom are required in great detail unless the cost of operation suddenly begins to rise on account of the introduction of less efficient units or because the cost of repairs is excessive in the second-hand outfits. It is not a hard task to keep such simple but complete records of the second-hand apparatus maintenance as are essential to the prompt detection of rising costs. On the side of operating efficiency, the plant records as a whole will, if properly planned, soon show any marked falling off in service economy, and, with individual maintenance records for the second-hand units, the approach of the inevitable time when the machinery should be discarded in favor of new equipment on account of its unreliability, its inadequate capacity, its inability to work in efficient harmony with the latest designs, or its abnormal repair and renewal charges, can be foretold soon enough to enable the operating company to plan a more modern installation.

A point of some difficulty which sometimes arises in connection with second-hand machinery is the wisdom of spending money for special shop appliances needed to maintain it suitably. On account of peculiarities in design or construction, a machine may be almost inaccessible for repair by the standard equipment of a shop arranged for the upkeep of a more modern installation. Every such case should be decided on its merits, but unless the reasons for purchasing are incontrovertible, as in the case of a plant which must have a large percentage increase of capacity at once to meet business demands that will support heavy repair, renewal and depreciation charges, it will rarely pay to spend more than a nominal sum on shop equipment for the special maintenance of second-hand apparatus. Here is a place where home-made expedients are invaluable, and any one who has followed electric railway repair shop practice in the past decade or two in a close way must see in that field an admirable illustration of how much can be done with ingenious contrivances in the maintenance of apparatus that no longer represents the best products of the manufacturer, but which still has serviceable life under the less exacting conditions of operating lighter cars at moderate speeds.

In the pressure upon an operating organization which often comes in behalf of the repair of the newer equipment, it is easy to neglect the second-hand machinery. It is axiomatic that the most important apparatus should receive first attention, but in almost all cases the second-hand units are the very machines which can least bear delay, once repairs are necessary. In the case of a power station breakdown, where a 1000-kw. turbine and a 2000-kw. second-hand engine unit are involved, it is not by any means certain that the best policy would be first to repair the more modern unit, provided the engine runs satisfactorily in parallel with the balance of the machines in the station. If such a case is rare in occurrence, it is by no means fanciful, and it shows the need of knowing, in each installation of new and second-hand machinery, just what can be done with the different combinations of units in the plant, and in such a juncture the existence of available records of the maintenance of the engine unit in the past might be a deciding factor in settling which machine should receive the most prompt attention. It might be possible, after a few hours or days, to carry on the repairs of both machines at once, but the presence of exact knowledge of each machine, new and second-hand alike, will enable a more intelligent decision to be made, and consequently one which will be less likely to subject the plant to another breakdown during the time of heavy demand upon it. When a double failure of apparatus occurs at the same plant, if the second-hand unit is a machine of very much smaller capacity, or if the newer unit can stand overloads better, so that the total available power will be greater if the newer unit is given the preference by the repair force, it is clearly the wiser policy to leave the second-hand repairs until a later time. Capacity rather than efficiency is important in case of failure of equipment, and if the output can be maintained better by first attending to the needs of a second-hand machine of large power, it is poor practice to devote one's time to the smaller but more efficient unit, for in emergency occasions the refinements of productive economy are less necessary than the preservation of continuous service.

It is often very difficult for operating officers to obtain the money needed for second-hand machinery maintenance, compared with the provision of funds for the repair and renewal of more modern apparatus. There is no harder question in any field of operation than the determination of how much it pays to spend upon a second-hand machine to keep it in decent operating condition. Nothing is more natural than for the executive officers of a company to feel that a second-hand machine once bought and placed in service should be allowed to wear out with little expenditure of additional money for its repairs other than that to keep it in service without too frequent breakdowns at peak-load times. Here is the final reason why some sort of record should be kept of the machine's repair costs and breakdowns. On the strength of such figures alone, one can arrive at the fair average sum of money that the company can afford to spend to prolong the life of second-hand apparatus subjected to important service.

The Rehabilitation of the Baltimore Street Railway Power System.

The task of reorganizing the distribution and generating system of the Baltimore electric railways is a type of work which called for more real skill on the part of the engineer than the construction of any new system of similar size. The latter work can generally be carried out along quite canonical lines and can be followed through in the ordinary sequence without any especial difficulties. To take a great railway system, however, and completely rehabilitate its power equipment without interfering with service and with careful economy always in mind calls for the shrewdest judgment and finest skill. One might almost say that any contractor can build a measurably successful power-house along the lines of the ordinary "catalogue engineering," but it takes a first-class engineer to build one power-house inside another without interfering with the service. This was pretty nearly the condition that confronted the engineer of the United Railways & Electric Co., of Baltimore, when he undertook the reorganization of the Pratt St. power-house. Following the Baltimore fire the city took advantage of the opportunity to widen Pratt St., thereby cutting off 50 ft. from the front of the power-house and forcing a move to the rear for apparatus space. Then the demand for power was rapidly growing and room must be provided not only for additional generating sets already ordered, but for still more in the immediate future.

For the renovated station the plan chosen was a pair of generating rooms separated by a double-decked boiler room. This arrangement had in point of convenience many advantages under the conditions of construction and is, moreover, a good one from any point of view, as it really gives a duplex generating plant in a very simple form. The full rated capacity of the station is 20,400 kw., with room for an additional 5,000 kw. turbine when needed. In a sense, the equipment is an exhibit of evolution in standard practice. The plant had already at the time of the fire gotten beyond the small direct-current generator stage, and its main equipment consisted of three 1,800-kw., direct-coupled, direct-current units, which had to be moved. A 5,000-kw., three-phase unit, with reciprocating engines, was the first step toward a larger service, followed up by a duplicate and then more recently by a 5,500-kw. Curtis turbine representing the latest stage of practice. All these big units are for 13,200 volts, looking forward to the future needs of the system in distribution. The switchboard system looks still further forward to a time when this power-house may be the point of control for a load of more than 100,000 kw. and is so planned that it can be gradually and systematically expanded to this immense capacity. Experience has shown that the power demand on the railways of a growing city is almost always underestimated, and many a system is to-day suffering from this condition. In American cities, at least, one does not deal with normal increase of the population alone, but with swift aggregation at the expense of the country districts; an aggregation which swells the population at a rate that is difficult to foresee. This condition is, in fact, one of the very troublesome things in attempting to provide for future rapid transit. One must build far ahead of apparent probabilities to keep anywhere nearly up with the game.

One of the interesting features of the railway situation was furnished by Bay Shore Park, a pleasure resort about 12 miles from the Pratt St. station. Until recently this park line was connected to the generating plant via the Eastern Ave. substation, which fed a nine-mile line with direct current from its rotaries. The necessity of adequate power for the considerable summer service was immediate, and it had to be faced on the existing basis of 25-cent copper. The result was a local station which in the interest of economy was put together mostly of material from the abandoned direct-current stations nearer the city. A reinforced-concrete station was constructed and in it were located four 200-kw. belted and a 200 and a 375-kw. direct-connected unit, together with a 3,300-volt, 250-kw. belted, three-phase machine for lighting the park. The engines are, in the main, compound, but non-condensing. The plant only has to run about four months per year, and the very low cost of this generating plant brings down the fixed charges, which would otherwise be heavy, to a very moderate figure. On the whole, it is a successful example of well-judged economy, although had copper been at its present price a regular substation might have been chosen instead.

A new substation at Lombard and Penn Sts. was the only radical addition to the system during the work of reconstruction. Here five 1,500-kw. rotary converters are in place, with room for three more. This is a thoroughly modern substation in all its appointments. The building is of brick, with concrete foundation, floors and roof, and accommodates all the apparatus on the main floor. The control system here is of the latest remote-control type. The single unusual addition to the equipment is a 300-kw. booster to handle an outlying line, for which the regular substation voltage of 575 is inadequate. The Northern substation, originally containing four 1,000-kw. rotaries, has been practically doubled in size and more than doubled in capacity, since it contains space for four 1,500-kw. units, of which two are already in place.

In both the substations and the main plant many modern conveniences have been installed, and the switchboard equipment in particular is thoroughly up to date. The lighting is chiefly from mercury arcs. Taken as a whole, the rehabilitation has been very extensive and thorough, although carried out under somewhat difficult conditions, and it has, moreover, been done very speedily, most of the work having been accomplished within eighteen months. The railway system is a burden that cannot be dropped when one wishes to modernize the plant, and provision for its growth must be kept up at all costs, even when stations are being remodeled almost from the ground up. The plants are now in a condition to be kept ahead of their requirements with a fair degree of ease, an acute necessity in a growing city like Baltimore. The whole work is an admirable example of resourceful engineering and hard and persistent work, and reflects great credit on the men who have pushed it through. It is a very striking thing to note the extent of necessary rehabilitation in electric traction. If one looks over the history of almost any railway system the depreciation due to changes in the art, for which great expense has to be incurred, is astonishingly great.

It runs not only through power equipment, but through rolling stock and track construction and represents one of the great, though frequently unconsidered, expenses of electric railway service, for which railway companies should get due credit.

Notes and Comments.

Boiler Scale Prevention is attained very easily at an Oklahoma water station, according to a statement by Mr. C. B. Purdon to Mr. Edward M. Shepard, author of a recent publication of the U. S. Geological Survey. The water used to supply one tank on the St. Louis & San Francisco R.R. contains a large amount of scale-producing salt, while that of another but a few miles distant contains substances which counteract the effect of these salts, so that a mingling of the two waters produces results so good that the locomotive engineers find no difficulty in their use.

A Track Platform Shelter of reinforced concrete has been constructed at the main railway station at Nuremberg, Germany, which resembles somewhat in its general appearance the platform shelters at the Hoboken terminal of the Delaware, Lackawanna & Western R.R., although the roofing is not carried up over the car so far as in the latter station. The reinforced concrete pillars which support the roof are 1.9 ft. square and about 33 ft. apart. The roof carried by each row of pillars is 25 ft. wide, higher at the edges than in the center.

A 2,000-ton Rapid Forging Press has recently been built by Messrs. Davy Bros., of Sheffield, England. The total weight of this press and of the gear for working it is about 350 tons, the crosshead alone weighing 40 tons. The main feature of the press is the fact that it makes from 70 to 80 strokes per minute. The press is fitted with a new type of continuous running gear provided with a clutch which slips during the instant of pressing, so that any loss of time in stopping and starting the turning gear is avoided. The press is built to handle ingots up to 48 in. in diameter, and for forging and finishing a shaft of from 20 to 25 ft. in length at a single heat. It is fitted with hydraulic mandril gearing for facilitating the making of hollow forgings, and also with hydraulic drill-changing gear.

Operating Costs of Motor Vehicles for commercial purposes are naturally scanty, as vehicles of this type have been in service such a comparatively short time. An English firm that has had 31 large motor vans in operation for two and a half years has made public the detailed cost of operating these vans, which replaced 31 four-horse vans. The running cost of each of the latter, including depreciation at 20 per cent, repairs to the chassis and body and tire renewals were $1,800 for 16,800 miles, or less than 10 cents per mile. The operating cost of the four-horse van which each of the motor-driven vehicles replaced, was 13 cents per mile for 14,000 miles. Stable expenses are also said to have been reduced since the introduction of the motor vans, and with an equal number of vehicles the road mileage has been increased at the rate of 90,000 miles per annum.

The Lake Michigan Water Commission has made its initial move in the broad investigation of the pollution of that lake and of means of removing the sources of this pollution, with a view of preventing their recurrence. A meeting of the commission is to be held at Grand Rapids, Mich., on May 30, prior to which an endeavor is being made to obtain certain definite information that may be used as a basis of the deliberations at that time. The members of the commission from the four States bordering on the lake have been requested to furnish data on the following eight points: The amount of sewage which enters the lake at present; the amount of water now being removed from the lake for domestic supplies; the relation of the outlets of sewers and polluted streams to water-works intakes; the effects of local currents, if any, on water supplies; the methods of sewage disposal now in use by the various municipalities; present practice with regard to the treatment of water for municipal supplies; the typhoid-fever death rate in the various municipalities; and present information as to the quality of the water furnished by the various municipalities. Much of this information can be secured almost without expense, but it is essentialy basic to the inauguration of the extensive investigation to be conducted. The commission expresses by this first action a most comprehensive policy that is to be followed in protecting Lake Michigan from contamination as a community interest to the great urban population dependent on that lake as a source of domestic water supply.

The Guayaquil & Quito R. R., in Ecuador, extending 300 miles inland from the coast to the capital of the country, has recently been opened for traffic. This railroad was started over thirty years ago, but it has only been during the last ten years that its construction has been carried on broadly. From 40 to 50 miles inland from the ocean terminal the line crosses country that is typically tropical in physical characteristics and climatic conditions. The broken western slope of the Andes Mountains rises abruptly for 50 miles from the edge of this tropical strip to a plateau 11,000 ft. above the sea, and from the top of this slope to the city of Quito the country is not so rough. The first 120 miles of construction, including a large amount of heavy grading, switchbacks and numerous novel structures, was placed in operation over four years ago. The tropical section was built by Jamaican negroes imported by the contractors for the construction of the line to the summit, the Jas. P. McDonald Co., of New York. All the supplies, including cement for the masonry, had to be transported for the heavy mountain work by pack trains. The first step in the construction of this section was necessarily the building of a trail, which involved a large amount of difficult work. As it was almost impossible to use any grading machinery on the mountain section, most of this work was done by hand. The completion of the remainder of the line provides direct communication by rail with the sea for Quito and the surrounding region. This region is remarkably fertile, and was settled nearly 400 years ago by the Spaniards, but it has heretofore depended entirely on trains of mules for transportation, so that its development has been greatly retarded.

Sault Ste. Marie Canal Traffic for the season of 1907 reached a grand total of 58,217,214 tons, which shows a net increase of 12 per cent., or 6,466,134 tons as compared with that of the season of 1906. The net registered tonnage of 44,087,974 is an increase of 7 per cent., or 2,989,650 tons over the previous season. While the totals give a large percentage increase, the latter including coal, flour, wheat and iron ore, the passages through both the American and the Canadian canals numbered 20,437, showing a loss of 1,718, or 8 per cent. This large decrease in the total number of passages is apparently due to the increasing size of new vessels engaged in lake traffic, and the gradual elimination of smaller craft. The traffic through the American canal was 73 per cent. of both the total freight and total net registered tonnage entering and leaving Lake Superior; but the total freight traffic through the canal was 6 per cent less, and the net registered tonnage 8 per cent. less than carried during the season of 1906. The Canadian canal, on the other hand, received an increase of 137 per cent. in total freight and of 92 per cent. in net registered tonnage. It is therefore evident that the two locks on the American side have practically reached the limit of their capacity, so that the large increase in traffic was necessarily handled chiefly by the Canadian lock. The work of widening the canal approach to the American locks, which has just been started, is designed as a part of a plan including a much needed large third lock that will relieve the present conditions. The recent completion of the West Neebish Channel in St. Mary's River below the canals greatly facilitates the passage of vessels through that river. Consequently, provision of the third American lock at Sault Ste. Marie and the extensive improvement of the Detroit River now under way will mean more to navigation than any previous similar work that has been undertaken.

The Natural Resources Conference of the Governors of the States, together with a few experts, including especially the presidents of various organizations interested in these resources, that was held this week at Washington at the invitation of President Roosevelt, was of remarkable character. The personnel of those present was alone sufficient to make the deliberations of the meeting of thoroughly national interest. Aside from that phase, the comprehensive movement thus inaugurated is of broad significance to the future development of the country. The conservation of our national resources has until the last few years received comparatively little attention, since many of these resources have been considered to be almost unlimited, and the tremendous potentiality in the development of others has not been appreciated. The alarmingly serious shortage of available lumber, the already evident increase in the cost of working deeper and more difficult deposits of coal as those more favorably located are exhausted, and other similar conditions are, however, now clearly apparent. The soil resources of the United States are likewise of wonderful magnitude, forming one of the greatest basic elements of our national growth; still, there is no question but that the full value of soils is rarely developed in agriculture as now practiced and that the fertility of soil is often needlessly depleted. The marked effect on stream flow due to the destruction of forests and the cultivation of lands in watersheds of streams has been thoroughly evidenced. On the other hand, vast areas of land remain to be reclaimed by drainage and irrigation, and the improvement of navigable streams as a part of the development of the interior has been widely urged. Much has been done by the general government, and individually by the states, in an endeavor to create a public appreciation of the possibilities of properly conserving the natural resources and of avoiding the wasteful methods followed by various industries. Although most excellent results have been accomplished in many of the different fields in which activities have thus been conducted, work of this character frequently involves several neighboring states, or is clearly of national scope. In fact, it can scarcely be carried on except by the general Government. The conference at Washington, at the invitation of President Roosevelt, to discuss the general features of the conservation of our national resources, is consequently most opportune. The preliminary program of this conference, as given in the Current News Supplement of this issue of The Engineering Record, and the attendance at the conference indicate the interested response that was made to the invitation. The results of this first meeting must essentially be general, but they are fundamental, and will doubtless lead to definite, culminative action of national effect.

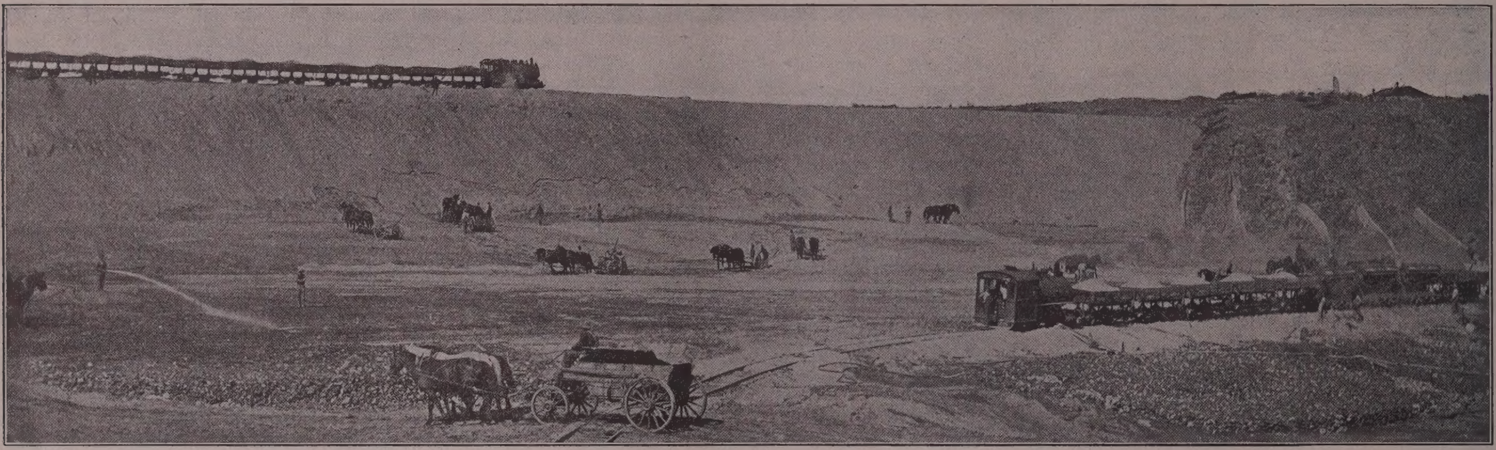
COMPARATIVE COSTS OF EARTHWORK.

By A. P. Davis, Chief Engineer, United States Reclamation Service.

During the six years of the operation of the Reclamation Act, twenty-six different projects have been undertaken, and one has been completed. The engineering features of the different projects are widely various, and some of them rather novel. Most of them involve water storage, and in the majority of instances this is accomplished by means of one or more earthen dams, a few of the more important of which have been selected as the subject of this article.

Cold Springs Dam.—The Cold Springs dam, now nearly finished, is 100 ft. in height, and forms a reservoir in Cold Springs Canyon, with a capacity of about 50,000 acre feet. It is being filled by a feed canal about 25 miles in length, diverting water from the Umatilla River and having a discharge capacity of 300 cu. ft. per second. The dam is eight miles from the nearest railroad station, and the road is very sandy. The cost of lignite coal at the dam site is $8.62½ per ton.

The foundation and left abutment of the dam are of earth, while the right abutment is volcanic rock. A cut off trench was excavated to depths varying from 6 to 20 ft., under the upper toe of the dam, and this trench was filled with good material well puddled and rolled in place. A series of eight concrete wing-walls, 1 ft. in thickness at the top, form the bond between the right abutment and the dam. One of the accompanying illustrations shows this dam under construction, indicating the methods of transporting, spreading, mixing, sprinkling and rolling the materials. The concrete cut-off walls joining the end of the earth bank to the right abutment are also shown in this view.



Construction Methods Employed on Cold Springs Dam, Umatilla Project, Oregon.

An extensive bed of fine gravel occurs on the side of the canyon below the dam, and this is the principal material of construction. The gravel contains considerable coarse sand, but is so open that it would not alone form a watertight structure. Accordingly, the gravel in the body of the dam, for one-third its thickness nearest the water slope is mixed with an equal volume of loam obtained in the vicinity, and the middle third is one-fourth loam and three-fourths gravel. The down stream third is composed of the run of the gravel bank, which is nearly pure gravel and coarse sand. The water slope of the dam is covered with 1 ft. gravel, and both slopes blanketed with rock as it comes from the quarry, being jagged irregular stones from 10 to 100 lb. in weight, pitched to a thickness of 2 ft. on the inner and 1 ft. on the outer slope.

The face of the gravel bank is from 20 to 50 ft. in height and is overlaid with loam from 2 to 10 ft. in depth. Where the loam layer exceeds 8 ft. in depth it is loosened in advance by powder. The gravel, clean or mixed with loam, is loaded in 4-yd. dump cars by a 70-ton Marion steam shovel, with a 2½-yd. dipper. The average length of gravel haul is about 2.3 miles, with a considerable proportion of up-grade on a slope of 1¼ per cent., the total rise from the gravel bank to the summit of the track being 65 ft. There is one switch-back on this track entailing the corresponding delay to each train load. Four trains, consisting each of one locomotive and ten 4-yd. dump cars, are employed to transport this material, yet frequently the shovel has to wait for cars.

In the beginning of construction a trestle 65 ft. in height was built across the canyon, and the gravel was dumped from that until the dam reached the height of the trestle, when the track was laid on the downstream edge of the bank and raised and drawn in as the work progressed. The gravel is removed and spread by means of four-horse fresno scrapers, of which eight are employed for this purpose. Two men and a dump cart are employed removing boulders occurring in the gravel, which are dumped on the face for riprap.

The output of the shovel has occasionally reached a maximum of about 2,300 yd. in a day of eight hours, and the average has been about 1,600 yd. or 200 yd. per hour. The cost of the principal equipment delivered on the work and ready for operation used in handling gravel is as shown in the accompanying Table 1:

TABLE 1.—COST OF PRINCIPAL EQUIPMENT, COLD SPRINGS DAM.

Items.	Cost.	Depreciation.
One steam shovel, 70-ton, 2½ yd.	$14,147	$8,147
Four locomotives, 16-ton	15,121	7,051
Forty-five dump cars	13,872	9,102
Four miles 30-in. track, 35-lb. rails.	25,187	20,447
Trestle	10,263	9,263
Sundries	.....	270
Total	$78,590	$54,280

The total depreciation on the equipment has been figured at $54,280. The total amount of gravel required is estimated at 590,000 cu. yd., making the cost of depreciation of plant per cubic yard moved, 9.2 cents.

The loam is excavated chiefly by means of an orange peel excavator, by which it is loaded into dump wagons that haul and place it where needed to mix with the gravel. Where convenient, some of the loam is hauled in fresno scrapers, and in portions of the cut-off trench wheel scrapers are used. The loam is dumped in piles from the wagons, and spread by means of a road machine into a layer of 3 to 4 in. Upon this the fresnos spread an equal layer of gravel, after which these two layers are mixed by three two-horse cultivators. Disc harrows were at first employed for this purpose, but proved to be not efficient, so were discarded. After the cultivators have mixed the layer it is thoroughly wet with three lines of sprinkling hose, and then rolled with two 5-ton loose disk rollers, each drawn by six horses, and forms a compact layer of 6 in. The cost of gravel embankment and of the earth embankment to April 1 is as given in Table 2:

TABLE 2.—COST OF GRAVEL EMBANKMENT AND OF EARTH EMBANKMENT, COLD SPRINGS DAM.

Gravel Embankment:	Cents.
Excavation by steam shovel	3.5
Hauling, railroad maintenance, etc.	7.0
Spreading and mixing	8.8
Sprinkling	1.0
Rolling	.5
Engineering, superintendence and general expense	5.7
Repairs	.5
Depreciation of plant	9.2
Total cost per cubic yard	36.2
Earth Embankment:	
Loading and hauling	9.5
Spreading and mixing	3.8
Sprinkling	1.1
Rolling	.8
Depreciation	4.2
Repairs	.3
Engineering, superintendence and general expenses	3.7
Total cost per cubic yard	23.4

As the dam is approximately one-fourth loam and three-fourths gravel, the combined cost is 33 cents per cubic yard, measured in excavation. The thorough mixing and compacting causes a shrinkage of about 16 per cent., making the cost in embankment about 39 cents.

Advertisement called out two bids, the lowest of which was 31 cents for earth and 45 cents for gravel, or a combined rate of 41.5 cents. Omitting the items of engineering and general expenses, which would have been incurred by the United States had the work been done by contract, the cost under force account is 30 cents. The bid is therefore about 38 per cent. higher than the cost by force account.

The Cold Springs dam and the project of which it is a part was planned by Mr. D. C. Henny, supervising engineer, and Mr. E. G. Hopson, assistant supervising engineer, Pacific Division, in consultation with Mr. A. J. Wiley. Mr. J. T. Whistler is engineer in charge of the project and the dam is built under the immediate superintendence of Mr. B. H. Davis, engineer.

Upper Deer Flat Embankment.—The upper embankment of Deer Flat is to be carried to a height of 68 ft. and a length of 3,930 ft., and will contain over 1,000,000 cu. yd. of earth and gravel. The water slope is 3 to 1 and the lower slope 2 to 1. The slopes will be blanketed with the coarsest gravel obtainable in the vicinity.

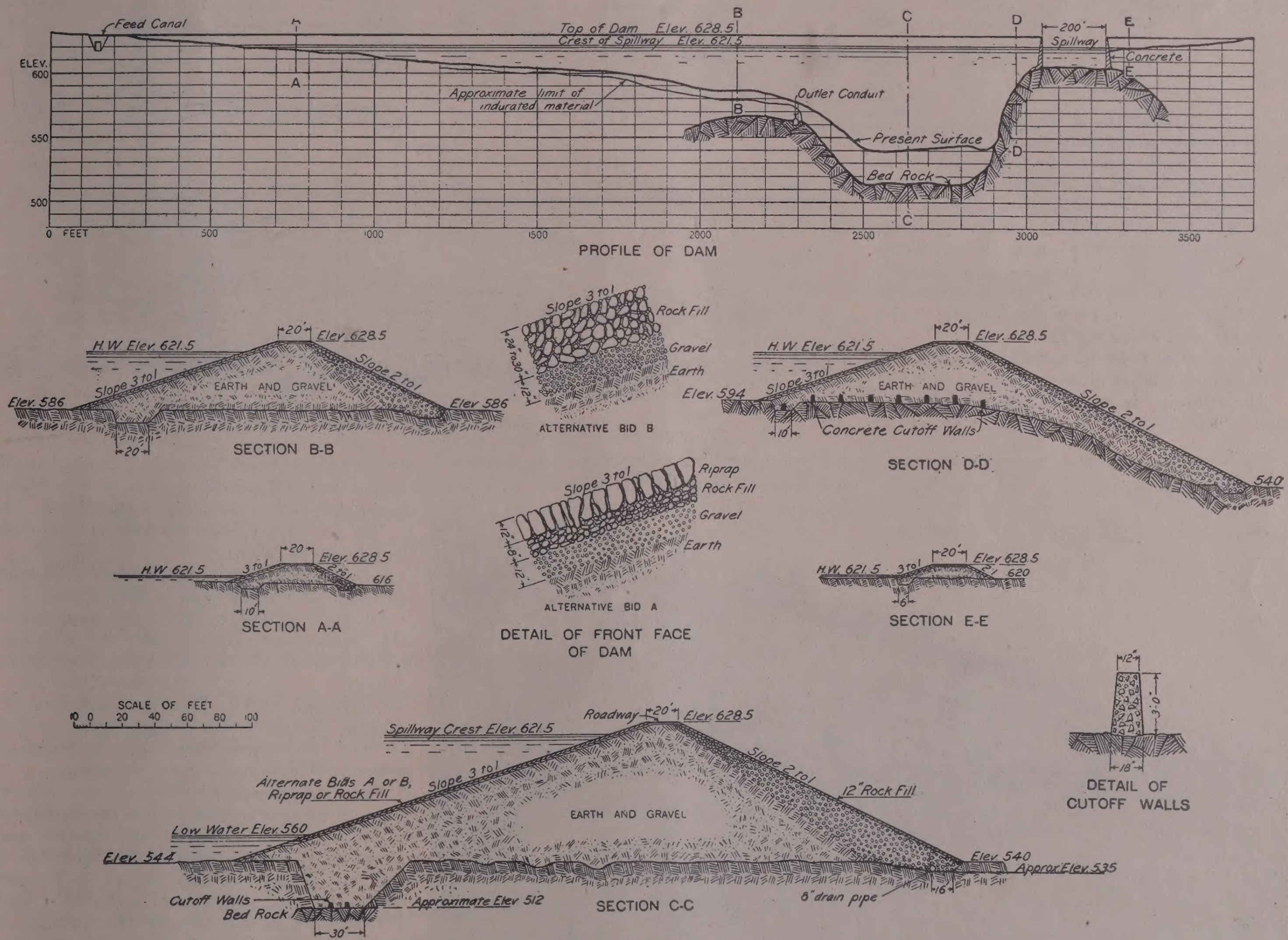
This structure was advertised and the three bids on the earthwork were 36, 37 and 37½ cents per yard, respectively. After careful consideration of the cost these bids were rejected as being too high, and the work was undertaken directly by the Government.

The following equipment was provided and is being used to build the dam and outlet, at a total cost of $77,000: Two 70-ton Atlantic steam shovels, four locomotives, sixty dump cars, 427,000 lb. rails, two road machines, five sprinkling wagons, one steam pump, one concrete mixer, two concrete rollers and miscellaneous tools.

The material is excavated with steam shovels and two trains of 12 cars each attend each shovel.

The material is generally a sandy gravel with small varying proportions of clay. Some selection is exercised to get the material showing considerable proportions of clay in the upstream half of the dam. A few feet under the natural surface of the ground is a stratum of hardpan usually several feet in thickness, to loosen which some powder has been used. Indurated chunks appear on the bank and a laborer is employed with a sledge hammer to pulverize these.

The railroad track is laid directly on the dam, and after dumping a train load of material the track is moved about 14 ft. by hitching to it a heavy span of horses and dragging it sideways, repeating the operation at suitable intervals. Very little alignment with bars is found necessary and the track is ready for another train load. In the meantime, other trains may dump from other parts of the track, and it is easy for two men and one heavy span of horses to attend to the track movement for two trains of cars, until the edge of the dam is reached, when some assistance is necessary to start the track on its way back.



Longitudinal Profile and Cross-Sections of Cold Springs Dam, Umatilla Project, Oregon.

This method distributes the material so evenly over the dam that two road machines are ample to complete the spreading of over 300 cu. yd. per hour. After spreading, heavy four-horse sprinkling carts are employed to thoroughly wet the material, and are also very effective rollers. Grooved concrete rollers are also employed to complete the packing. This work is five miles from Nampa, the most available railroad station, and lignite coal costs $8 per ton at the site.

The constructing engineer to expedite the work decided to pay a premium for large output. In addition to the regular wages, for all yardage over 22,000 cu. yd. per shovel per month, reckoning from fifteenth to the fifteenth of each month, a yardage bonus has been paid the steam shovel and locomotive men and track foremen as follows: Steam shovel runners, 2/3c.; steam shovel cranesmen, ½c.; steam shovel firemen, 1/3c.; locomotive engineers, ½c.; track foremen, ¼c., making a total cost of 3¾ cents per yard.

The costs of this work to the first of March are shown in Table 3:

Table 3.—Cost of Upper Deer Flat Embankment.

	Per yard
Excavation	6.3
Hauling	8.3
Spreading	1.8
Sprinkling	1.8
Rolling	1.3
Depreciation	4.1
Engineering, superintendence and general expenses	3.9
Total cost per cubic yard	27.5

Eliminating the items of engineering and general administrative expenses, which would have been incurred had the work been contracted, we have a cost of about 26 cents per yard, as against the lowest bid price of 36 cents.

Lower Deer Flat Embankment.—The Lower Deer Flat Embankment is a part of the Payette-Boise project, Idaho. It was built under contract by Messrs. Hubbard and Carlson, and was completed in January, 1908. It is 7,350 ft. long and the greatest height is 43 ft. The body of the dam is of earth obtained from borrow pits within the reservoir. A blanket of gravel 3 ft. thick is spread over the water face, and the downstream fourth of the dam is entirely of gravel.

The earth was loaded into dump wagons by elevating graders, and a small portion was placed by wheel scrapers. Road machines were used for spreading, and sprinkling carts for sprinkling.

The gravel was obtained from borrow pits near the north end of the dam, the bottom of these pits being nearly level with the top of the dam, so that most of the haul was either downhill or level. The average haul for gravel was about 4,000 ft., and was made by locomotives and dump cars. The loading was done by a 60-ton Vulcan steam shovel. The principal equipment used on this dam is as follows, the total cost being $50,000: One Vulcan 60-ton steam shovel, two locomotives, thirty-two dump cars, 1½ miles rails and switches, four elevating graders, two road graders, forty-eight dump wagons, two traction engines, sixteen fresno scrapers, five tongue scrapers, nine slip scrapers, seventeen wheel scrapers, four sprinkling wagons, two concrete rollers, four small gasoline engines, three small centrifugal pumps, fifteen plows, one derrick and miscellaneous tools.

The contract prices were 24 cents per yard for earth and 35 cents per yard for gravel. Allowing a salvage of only 20 per cent. on equipment, the total cost to the contractor was 21 cents per yard for earth and 29 cents per yard for gravel, exclusive of administrative expenses, which doubtless left him a satisfactory profit.

Mr. D. W. Ross is supervising engineer for Idaho. Mr. F. C. Horn, constructing engineer, is in general charge of both embankments and also of other construction work. The upper embankment is under the immediate charge of Mr. R. M. Connor, and Mr. J. T. Burke had charge of the lower embankment.

Belle Fourche Dam.—The dam across Owl Creek, near Belle Fourche, South Dakota, will be 115 ft. high, 6,500 ft. long and contains 1,600 cu. yd. of earth. The reservoir will catch the storm waters which occasionally flow down Owl Creek, but the chief source of supply is a feed canal taking water from Belle Fourche River.

The maximum cross section of Belle Fourche Dam as designed is shown in an accompanying illustration; the dotted line at the water toe, on a slope of 5 to 1, shows a modification made since construction began.

The construction of this dam was contracted in 1905, to Messrs. Orman & Crook, contractors of large experience in railroad and other construction work. The price bid for the embankment was 28 cents per cubic yard measured in excavation.

Table 4.—Progress on Belle Fourche Dam.

	Total Embankment.			Steam Shovels.			Graders.		
Date	During Month.	Days.	Av. p. Day.	During Month.	Days.	Dly. av. p. shov.	During Month.	Days.	Dly. av. p. Grader.
1906.									
June	2,500	5.0	500	500	1.0	500	2,000	5.0	400
July	51,440	26.0	1,980	20,450	25.0	818	30,990	43.0	721
Aug.	55,700	24.0	2,320	25,700	23.0	1,120	30,000	48.0	625
Sept.	52,000	26.0	2,000	27,000	25.0	1,080	25,000	40.5	618
Oct.	37,500	25.5	1,470	21,000	25.5	824	16,500	36.5	452
Nov.	20,080	13.5	1,485	11,425	12.5	915	8,655	13.5	642
Totals	219,220	120.0	1,825	106,075	112.0	947	113,145	186.5	607
1907.									
Apr.	2,400	2.5	960				2,400	5.0	480
May	19,455	17.0	1,140				19,455	42.0	465
June	27,510	21.0	1,310	19,100	21	910	8,410	16.0	530
July	39,798	22.0	1,810	25,074	23	1,090	14,724	33.0	447
Aug.	56,407	26.5	2,125	42,385	47	902	13,922	26.5	525
Sept.	46,623	21.5	2,165	36,510	30	1,215	10,113	19.0	533
Oct.	59,387	27.0	2,200	46,750	46	1,015	12,637	23.0	550
Nov.	29,900	22.0	1,360	25,840	39	663	4,060	7.0	580
Dec.	3,650	3.0	1,217	3,650	3	1,217			
Totals	285,130	162.5	1,750	199,309	209	956	85,721	171.5	500

Little more than preparation was done on this contract until the summer of 1906, since which the progress has been as shown in Table 4.

The only material available is adobe clay. No rock is found in the vicinity, and the pavement to protect the water slope is to be concrete blocks built in place. For this purpose it is necessary to haul the sand and gravel over six miles. The dam is 12 miles from the nearest railroad station and coal costs $10.50 per ton.

The principal items of equipment employed by the contractor are as given in Table 5.

The following is the general method of computing depreciation: The two steam shovels at the factory cost $17,000; and on the work, including freight and moving to borrow pit, the cost was $23,196. It is assumed that at the end of four or five years, when the work is completed, the shovels on the job will be worth about 20 per cent. of the factory cost, or $1,700 each, to which should be added $2,300 for moving 16 miles to the railroad at Belle Fourche, giving the value at latter point about $4,000 each. Subtracting salvage of $3,400 from cost of $23,196, gives total depreciation of $19,796 to assess against about 1,300,000 cu. yd. to be done by steam shovels. The average daily output of a steam shovel has been about 950 cu. yd., or 1,300,000 ÷ 950 = 1,369 days' work for one shovel, and $19,796 ÷ 1,369 = $14.50, or say $15 per day worked.

Class of Material Being Placed on Downstream Face of Lower Deer Flat Embankment.

Table 5.—Cost and Depreciation of Equipment, Belle Fourche Dam.

	Cost.	Depreciation.
Two steam shovels.....................	$23,196	$19,796
Six locomotives (18 ton)...............	21,462	15,312
Sixty-six dump cars (4-yd.)............	16,656	14,196
Two graders..........................	2,568	1,998
Two road levelers.....................	500	350
One 12-ton roller......................	1,580	1,280
Four 32-h.p. traction engines (21 tons)..	9,939	6,989
Water system (pipe, hose, dams, well, pumps, boilers and labor)............	19,333	15,733
Bridges, shops, etc....................	4,500	4,200
Two miles railroad track (35-lb rail) laying and relaying, etc................	20,075	15,685
*Twenty-four 1½ cu. yd. Aurora dump wagons	2,400	
One hundred horses and mules, with plows, scrapers, etc..................	12,000	
Total	$134,209	$95,539*

*Note:—Cost less Depreciation equals assumed value of plant on the job at completion of contract. The last two items in table are covered by the rate of $1.15 per day allowed for horses at work.

The water system has cost $19,333; and salvage on boiler, pump and water pipe is estimated at $3,600, leaving $15,733 to charge against 1,600,000 cu. yd., or $0.01 per cubic yard of embankment.

The adobe of which the dam is building is very difficult to handle unless the moisture conditions are just right. When wet, the adobe is sticky and refractory. When dry it bakes very hard and pulverizes into a fine powder, which forms dense clouds of dust, especially on a windy day.

Two steam shovels load the material into 4-yd. dump cars, which are drawn in trains of 10 cars by 18-ton Davenport locomotives. The average haul is about one mile. In addition to this, a portion of the work was done by elevating graders and dump wagons.

The material transported by cars, which is the greater portion, was spread in 6-in. layers by means of four-horse Fresno scrapers, for a distance of 50 ft. on each side of the track. The tracks were shifted in position 10 ft. after the deposition of every third layer. The material deposited by the dump wagons was spread with road machines. The wetting was done with hose supplied by pipes and pumps from a temporary reservoir.

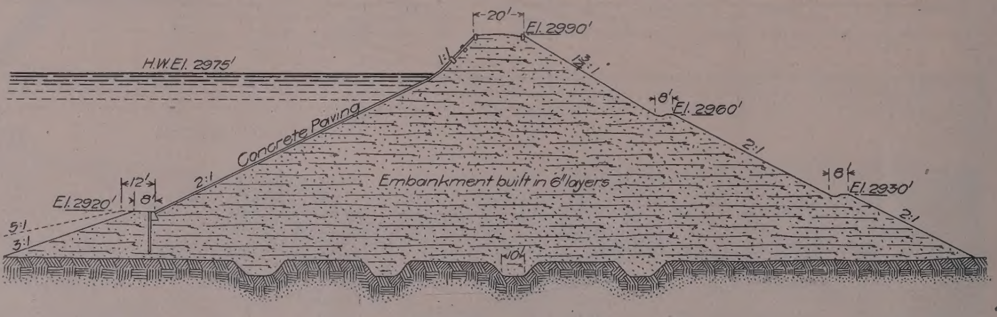
The cost of water for sprinkling and for boiler use has been exceptionally heavy. This was at times provided by temporary earth embankments to store the storm water of Owl Creek; but this supply was so precarious that the contractor bored two artesian wells, each 1,430 ft. deep. The rolling was done by a 21-ton traction engine and a 12-ton road roller.

The material occupies about 1 per cent. more space in embankment than in excavation.

Mr. R. F. Walter is the project engineer, and the construction work is under the immediate supervision of Mr. W. W. Patch, constructing engineer.

Table 6.—Cost of Earthwork on Belle Fourche Dam.

Item.	Steam shovel work. 305,000 cu. yd.	Grader work. 199,000 cu. yd.
Loading	$0.067	$0.054
Hauling	.079	.113
Spreading	.101	.015
Sprinkling	.015	.013
Rolling	.012	.015
Depreciation and repairs......	.091	.034
Administration	.033	.022
Total cost per cubic yard....	$0.398	$0.266
Aggregate total cost.........	$121,338	$52,814



Cross-Section of Belle Fourche Dam.

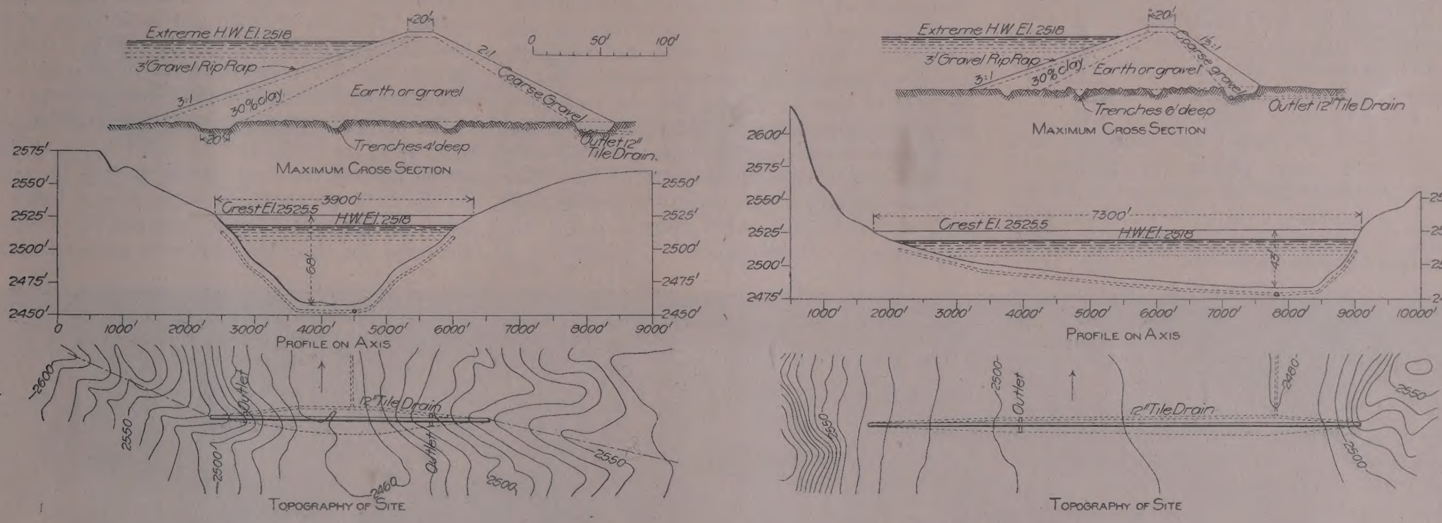
Comparison with Eastern Conditions.—To facilitate the application of these figures to similar work in Eastern States, some discussion of comparative conditions may be of value.

The most important difference in conditions between the East and the West is the discrepancy in prices of labor, equipment and supplies, these all being much more costly in the West than in the East. This is especially the case in the intermountain region, where most reclamation work is located. Coal, for instance, is a striking example. In the East good bituminous coal can be obtained on an average of $4 or $5 per ton, delivered at the work, while on the work herein described the price is from $7.50 at railroad to $10.50 on the work, and this is for lignite, which has less than two-thirds the value of bituminous coal for this purpose, thus making the fuel cost about three times as heavy in the West as in the East. For work using steam shovel and locomotive, this adds from 2 to 3 cents per yard to the cost of Western over Eastern work.

The most important advantage of Western conditions is in the climate. In an arid region the delays from rain are, of course, less frequent than in a humid climate. There are other conditions that tend to modify this, for instance, the frequent high winds of the plains region, which aggravate the dry, dusty conditions that surround construction work. Horses have been known to die of a disease resembling lung fever from inhaling the dust on excavation work. This cause frequently prevents work and hampers it when in progress.

The progress on the Belle Fourche Dam given in Table 4 shows the number of days worked in each month, which represents all the days in which work was climatically practicable, and from this it may be seen that there is no material difference in the number of good working days in South Dakota and the Eastern or Middle States.

West of the mountains, where the climate is drier and less windy, the climatic advantage is decidedly with the West. The Columbia drainage, in which are situated the Umatilla and Deer Flat dams, is a fair example.



Details of Upper and Lower Embankments, Deer Flat Reservoir, Payette-Boise Project.

TABLE 9—COMPARISON OF EMBANKMENTS BUILT BY THE UNITED STATES RECLAMATION SERVICE.

	Upper Deer Flat.	Lower Deer Flat.	Cold Springs.	Belle Fourche.	Minidoka.	Avalon.	Hondo—Emb., No. 5
1. Reservoir capacity, —acre-feet.	170,000	*a*	50,000	200,000	60,000	5,600	40,000
2. Height of dam, ft.	68	43	100	115	80	48	20
3. Length of dam, ft.	3,930	7,350	3,000	6,500	660	1,000	4,000
4. Total yardage	1,000,000	950,000	600,000	1,580,000	Rock, 75,000. Earth, 110,000.	(85,000, earth.) 120,000, rock.	288,000.
5. Material	Earth, gravel	Earth, gravel.	Sand, gravel, loam.	Clay.	Earth, gravel, rock-fill	Earth, rockfill, concrete corewall.	Earth.
6. Upper face protection	Gravel riprap, 3 ft.	Gravel riprap, 3 ft.	Riprap, rough.	Concrete paving.	Riprap, 2 ft. (upper part.)	Riprap, 1 ft.	Riprap, 1 ft.
7. Manner of construction	Force account.	Contract, Hubbard & Carlson.	Force account.	Contract, Orman & Crook.	Contract, Bates & Rogers.	Force account.	Contract, *b* Taylor Moore Con. Co.
8. Steam shovels.	2 Atlantic.	1 60-ton Vulcan.	1 Marion. 1 Orange Peel.	2 Vulcan; also elevating graders.	Orange peel.	None.	None.
9. Transportation	Locomotive and cars.	Locomotive and cars—some with scrapers, graders, wagons.	Locomotive, cars and dump wagons.	12 T. Dinkeys and 4 yd. cars, wagons with horses.	Horses and cars for earth cableways for rock.	Horses and dump wagons.	Scrapers and graders.
10. Coal consumed per yard	10.5 ℔.		11 ℔.				
11. Cost of coal, ton	$8.00	$7.50	$8.62	$10.50			
12. Method of wetting	Sprinkling carts.	Sprinkling carts.	Pipe and hose.	Pipe and hose.	Immersion.	Sprinkling carts.	Sprinkling carts.
13. Cost of equipment	$77,263	$50,000	$106,000	$134,000			
14. Total estimated cost	$382,150	$256,550	$383,415	$879,164	$367,366	$195,000	$41,538
15. Unit price bid for earth excavation.	0.36	0.24 earth. 0.35 gravel.	Earth, 0.31. Gravel, 0.45.	0.28	Rock, 0.90. Earth, 0.80.	No bids.	0.12½
16. Unit yardage cost to date	0.194	0.180 body. 0.192 face and back.	Earth, 0.228. Gravel, 0.362.	0.323	Rock, 0.45. Earth, 0.41.	0.383	0.180
17. Percentage of earth fill completed at time of estimating unit cost	85	100	86	33	100	92	100

a 170,000 acre-feet is total in Upper and Lower Deer Flat Reservoir, formed by the upper and lower embankments. *b* Contractor failed; finished by force account.

For the purpose of comparing the climate, it has been assumed that there are eight working months in the year, and the rainfall records for 1906 and 1907 have been obtained from the Weather Bureau. From these records the days are noted in which the precipitation exceeded 0.2 of an inch, and it is assumed that this is the amount of rain required on the average to stop work for an entire day. The records are for Boise, Idaho, and Albany, N. Y., and the days in which work would have been stopped are shown by months in Table 7.

From Table 7 it will be seen that on the assumption as given work would have been stopped on the Upper Deer Flat project near Boise in the sixteen months given on 23 days; deducting this number from the total of 490 days, leaves 467 days of good weather. Deducting one-sixth of this for Sundays and holidays, we have left 389 working days, or 24.3 days per month.

TABLE 7.—COMPARISON OF CLIMATE IN BOISE, IDAHO, AND ALBANY, N. Y.

Days in which precipitation exceeded 0.2 of an inch.

1906.	Boise.	Albany.	1907.	Boise.	Albany.
March	2	5	March	6	1
April	2	2	April	2	4
May	4	4	May	0	6
June	1	8	June	3	5
July	0	6	July	0	4
August	0	6	August	0	0
September	1	4	September	0	8
October	0	4	October	2	6
Total	10	39	Total	13	34

By similar process, we find that at Albany in the same sixteen months, we would have had 347 days, or 22.2 working days per month. We may assume that the number of working days per month at the two places is 24 and 22 days, respectively.

Table 8 shows the wages at the two points of day laborers and of monthly employes on steam shovel work, on the assumption that monthly employees must be paid regardless of weather:

Eliminating the wages of daily employes for the days not worked and combining their wages with those of the monthly employes, the total amount paid in wages per working day is $122.67, Western, and $88.36, Eastern. This shows that, with full consideration for the climatic differences, wages are 39 per cent. higher in the West than in the East.

It may be said, and is generally true, that high wages are accompanied by greater efficiency of the laborer, but the difference in greater nominal wages in the Western United States is largely counterbalanced by the increased cost of most items of living, and less certainty of employment. At any rate, there does not appear to be any material difference in the efficiency of Eastern and Western labor.

The work herein described was done mainly under conditions of great shortage of labor and materials, and was frequently hampered by the freight congestion of the last two years. Table 8 gives about the average wages paid during the period covered. These have in a few cases been recently reduced. With reduced wages and a plentiful supply of laborers, efficiency has increased, and the work could now be done much cheaper than in 1906 and 1907.

Table 8.—Wages of Day Laborers and of Monthly Employes, Eastern and Western.

Day Laborers.		Western.		Eastern.
Two foremen....at	$4.00	$ 8.00	at $3.00	$6.00
Six pitmen......at	2.25	13.50	at 1.50	9.00
Two Lo. Eng.....at	6.00	12.00	at 3.50	7.00
Twenty train, track and dumpmen..at	2.25	45.00	at 1.50	30.00
		$78.50		$52.00
		24×		22×
		$1,884.00		$1,144.00
Monthly Employes:				
Shovel runner		$170 per mo.		$125 per mo.
Craneman		115		90
Three firemen............		300		225
One blacksmith............		100		75
One machinist............		100		75
One timekeeper............		75		50
One blacksmith helper......		75		.60
One superintendent........		125		100
Total		$1,060		$800
		1,884		1,144
		24)$2,944		22)$1,944
		$122.67		$88.36
Western wages per working day..................				$122.67
Eastern " " " "				88.36
Difference				$34.31

Excess of Western over Eastern wages after allowing for climatic differences, 39 per cent.

In the Northeastern States the working season will be shorter than eight months, but this would not greatly increase unit costs, though it would, of course, delay the work. This is offset by the fact that the comparison omits the effects of dust storms in the West. No claim to great accuracy is made for the above comparison, but it seems to illustrate the relatively small effect of climate on the cost of work.

The high freight to Western points, the isolation of many localities with the consequent expensive wagon haul make it so difficult to procure labor, equipment and repair parts, that frequent delays and losses occur from this cause. It seems safe to conclude that this class of work in the West costs necessarily from 25 to 50 per cent. more than in the East, depending on locality.

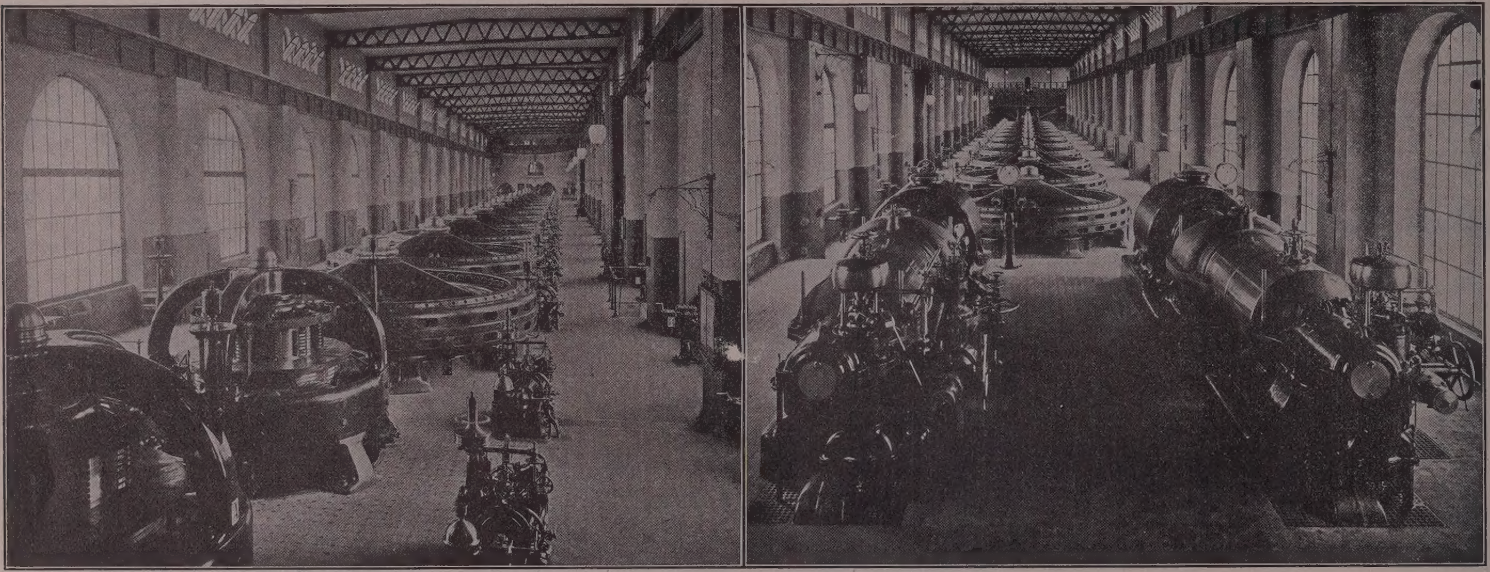
A Large Pneumatic Tube is under construction in Chicago between the Union Stock Yards postal station and the offices of Armour & Co. This tube is to be approximately one-half mile in length, 20 in. in diameter and will accommodate a carrier holding the contents of an ordinary mail pouch.

A Combined Steam and Hydraulic Generating Station in Switzerland.

By Frank Koester.

One of the most interesting power plants in Switzerland is located at Beznau on the Aare, interesting not only because it is a large station, but also because it is a combination employing high and low-water hydraulic turbines as well as steam turbines. It is the duty of the latter to take care of the fluctuations in the flow of the stream; it being particularly necessary, since no provision could be made for water storage, and sudden fluctuations arise, that quick steaming boilers be installed.

Prior to the installation of the steam turbines a combination of low and high-water hydraulic turbines had been installed so as to economically utilize the water available. With the constantly increasing demand for current, however, and as the limit of capacity of both low and high-water turbines corresponding to the water supply had been reached, the steam turbines provided were selected, with a view to take care of the future demands upon the station, which it is intended shall work in parallel with the "Loentsch" power station, in course of construction.



Two Views of the Interior of the Generating Room of the Station Building.

It might be stated here that to provide for the increased demand for current from time to time the development of the plant was made in the following manner: Six main hydro-electric units were first installed in November, 1902; three hydro-electric units in May, 1904; two hydro-electric units in August, 1905. For the foregoing units the building was originally designed and completed. In December, 1905, extensions to the building were provided for the steam installations, consisting of one turbine and three boiler units, and in November, 1906, one more steam turbine and three boiler units were installed. In addition, dwellings were erected for the operating force.

Dam and Headrace.—The River Aare makes a bend at Beznau, at the upper end of which the dam was constructed, and a straight headrace was run, practically at 90 deg. to the stream, to the lower end of the bend, where the power plant was located. This dam consists of concrete pilasters across the entire stream, provided with seven iron gates. These gates are arranged that they may be raised and lowered according to the water supply and, under ordinary conditions, the water does not flow over the top of these gates similar to the crest of a dam, but flows under them. This is done that sand and gravel may not collect in front of the gates.

The latter are of the Stoney design. They are each 49 ft. wide, made of structural steel, provided on the bottom with a square timber resting on a cast-iron shoe imbedded in the concrete of the dam. They are guided between the pilasters by means of rollers to facilitate easy movement and are counterbalanced. The sides of the gates are made watertight by steel ropes, which are held against the joint by the pressure of the water. Each gate may be operated by hand, two men being necessary, or for quicker action by an 8-hp. motor. Plans are at present in preparation for the installation of a hydraulic turbine at the dam for operating these gates in case of emergency.

At the side of the stream near the headrace is a fish step, designed, as called for by the laws of Switzerland, to permit the fish to ascend the stream. It is 6.5 ft. wide and is provided with four inlets. On the side of this step is a transformer station for operating the motors of the dam gates and for lighting the operating bridge.

The headrace is 3,870 ft. long and has a slope of 15 ft. to the thousand. The bed is 137 ft. wide at the bottom, the sides having a slope of 2:3. As the headrace crosses a public road a lattice-girder bridge, 14.75 ft. wide, with one pier in the middle of the headrace, had to be provided. At the mouth of the headrace and across its entire width is a deflecting wall, 4.7 ft. high above the bed, for preventing gravel and sand from entering, thus causing the gravel and sand to be swept through the gates of the dam. Directly behind this deflecting wall are fifteen iron sluice gates, each having a width of 16.3 ft., which are operated by hand from an overhead operating bridge. These gates also act as deflectors for floating materials such as ice and débris, so that these materials may not enter the headrace.

At the side of the power house, which extends obliquely across the headrace, is a sluice lock, 10 ft. wide and 50 ft. long, to permit the passage of a rowboat; also two draw-off gates, 19.6 ft. total width, for emptying the headrace, and, furthermore, an additional fish step.

The water before entering the turbines must pass a system of racks made of bars supported by structural steel. The inlet to each main turbine is provided with a gate, 10.5 ft. high and a clear width of 19.7 ft. Owing to the weight of these gates, and especially the great pressure of water against them, sometimes amounting to 75 tons, each one is operated by a hydraulic cylinder and oil pressure, for which purpose are installed two 50-hp. oil-pressure pumps.

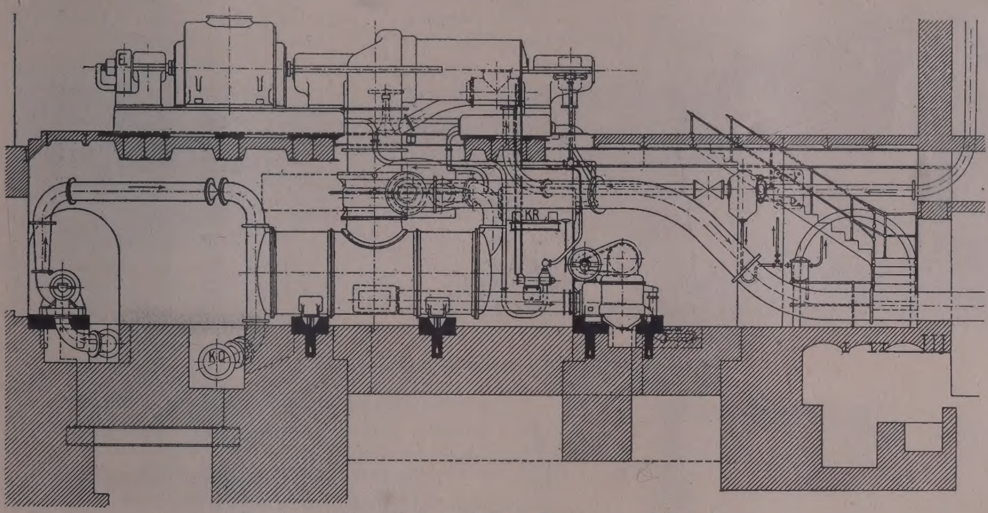
The gates for the exciter turbo-generator units are 11.8 ft. wide and 10.5 ft. high and are of the same design as the large gates.

The above-mentioned oil pumps are operated by means of gearing from the exciter units shaft. They are provided with oil-pressure accumulators and work under a pressure of 450 lb. per square inch. The same pressure oil is used under the step bearings of the turbines.

The rotary part of each turbine weighs 45 tons, while the buoyancy, with a head of 10.8 ft., is 12.7 tons, and with a head of 18.7 ft. is 23.7 tons, this giving a net pressure on the step bearing of 32.3 and 21.3 tons, respectively.

Each oil-pressure accumulator is provided with a special oil compressor operated by a motor.

For the purpose of making repairs to the turbines the individual chamber will be closed off both to the head and tail water. Iron gates provided for this purpose travel on a runway the entire length of the power house above the tail-race abutments. After a gate has been lowered two large centrifugal pumps are employed for emptying the chamber.


Sectional Elevation of Steam Turbine and Condenser.

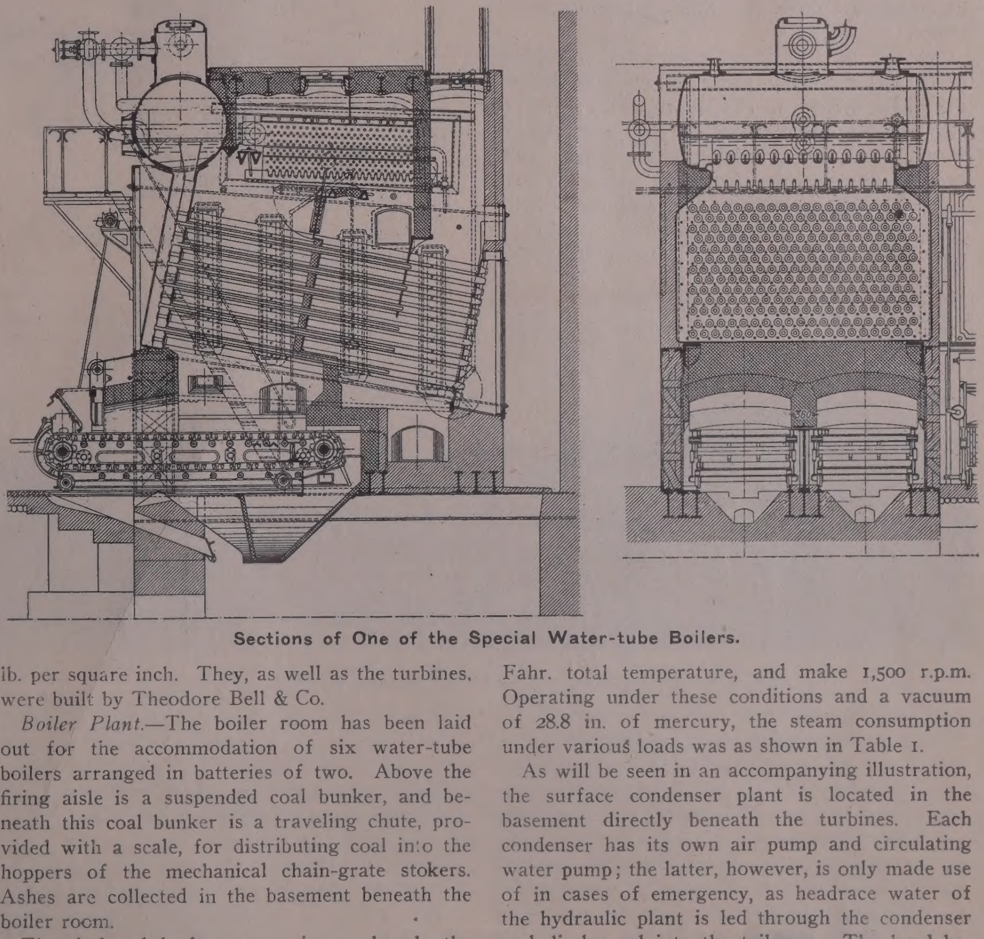
Building.—The substructure of the power house is of massive concrete. It is provided with eleven bays for the main hydraulic turbines and two for the exciter turbine units. The superstructure is of brick, with cement finish, all corners being of rough-cut stone. At one end of the turbine room is a switch house, and beyond this a repair shop. At the opposite end of the hydraulic turbine room are the steam turbines, while adjoining this end in a wing forming an obtuse angle is the boiler room, having a width of 36 ft. and a length, approximately, of 105 ft. The width of the turbine room for both hydraulic and steam turbines is 39.3 ft. in the clear, the length being 376 ft. The switch house has a width of 59.6 ft. and a depth of 41 ft. It contains three floors besides a basement. The repair shop building, consisting of a basement and two floors, is 39.3 ft. wide and 23.6 ft. deep.

The main operating floors are on the same level, for the purpose of convenient observation from the switch room controlling gallery, which is 9.8 ft. above the generator room floor. The boiler room floor is also on the same level with the main operating floors.

Hydraulic Turbines.—As will be seen in the accompanying cross-section, the turbines are all of the vertical type, three runners being mounted on a single shaft, two on the lower end of the shaft and one on the upper end, this shaft running at 66.6 r.p.m. The low-water turbines, of which there are six, develop 750 hp. each, with a head of 10.8 ft., while with a head of 12.8 ft. 1,000 hp. is developed by each of them. The high-water turbines each develop 900 hp. with a head of 10.5 ft., while with a head of 18.7 ft. they develop 1,200 hp. apiece; five high-water turbines are used.

The operation of the plant is so managed that all the low-water turbines carry the load up to their full capacity, and after which the high-water turbines are successively thrown into service as the load increases. This is done so that the low-water turbines may operate at their greatest efficiency, it being the intention that the greatest amount of power should be developed by the high-water turbines, while the efficiency of these turbines was a secondary matter. Under actual operating conditions, as above outlined, the efficiency of the low-water turbines was 81 per cent, although the guarantee of the manufacturer was only 76 per cent, and that of the high-water turbines was 66 per cent.

The regulation of the speed of the turbines is accomplished by hydraulic governors, which are located by the side of each generator. The governors work under a pressure of from 300 to 370 lb. per square inch. They, as well as the turbines, were built by Theodore Bell & Co.


Sections of One of the Special Water-tube Boilers.

Boiler Plant.—The boiler room has been laid out for the accommodation of six water-tube boilers arranged in batteries of two. Above the firing aisle is a suspended coal bunker, and beneath this coal bunker is a traveling chute, provided with a scale, for distributing coal into the hoppers of the mechanical chain-grate stokers. Ashes are collected in the basement beneath the boiler room.

The induced-draft system is employed, the blowers being located on top of the boilers and belt driven by motors. The blowers, of which there are two, make 335 r.p.m., the motors being 35 hp., and produce a maximum draft of 1½ in. The stacks are made of rolled steel, are 4.9 ft. in diameter and extend 49 ft. above the blowers.

Boilers with small water-storage capacity and rapid circulation were adopted to meet the quick-steaming requirements. Each boiler has a heating surface of 3,750 sq. ft. The boilers are made up of one front steam drum and one front header, which latter is divided transversely into two chambers by an upright partition. U-shaped tubes, 4 in. in diameter, are used, the two legs of these tubes being expanded into the back wall of the header. Into this partition wall of the header are inserted 2-in. tubes, which extend about three-quarters of the distance back into the U tubes, one into each leg of the latter. The circulation of the water and the rising steam is such that the incoming water enters the 2-in. tubes and discharges into the 4-in. U tubes. Back of the steam drum and above the tubes, in the boiler setting, is a superheater, with 125 sq. ft. of surface, which is capable of producing a total temperature of 750° Fahr., the steam pressure being 190 lb. Tests made show an efficiency of 70.2 per cent, while the superheater was 5.7 per cent, or a total of 75.9 per cent. With coal of 12,550 B.t.u., with 88 per cent calorific value, the evaporation was 7.9 lb. per pound of coal. The boiler evaporated 5.11 lb. of water per square foot of heating surface.

For measuring the carbon dioxide carried off with the gases an Ados CO_2 recorder, known in this country as the Sarco, is used.

TABLE 1.—STEAM CONSUMPTION OF TURBINES.

Load in kw.	2,400	2,000	1,000
Steam consumption per kw. hour, in pounds	13.9	14.2	16.2
Manufacturer's guarantee	16.7	17.1	20.1

Steam Turbines.—There are at present installed two Brown, Boveri-Parsons steam turbines, of 2400-kw. capacity each. These turbines operate under a pressure of 175 lb., with steam at 662° Fahr. total temperature, and make 1,500 r.p.m. Operating under these conditions and a vacuum of 28.8 in. of mercury, the steam consumption under various loads was as shown in Table 1.

As will be seen in an accompanying illustration, the surface condenser plant is located in the basement directly beneath the turbines. Each condenser has its own air pump and circulating water pump; the latter, however, is only made use of in cases of emergency, as headrace water of the hydraulic plant is led through the condenser and discharged into the tail-race. The head between the two water levels is sufficiently high to overcome the friction in the condenser. The utilization of the head-race water at low-water stages, which is equivalent to a high head, is of particular benefit, as a high vacuum may be easily maintained. In cases of emergency, when there is no headrace water, the centrifugal pumps draw the water directly from the river. Both centrifugal and air pumps are motor-driven, the former direct and the latter by chain.

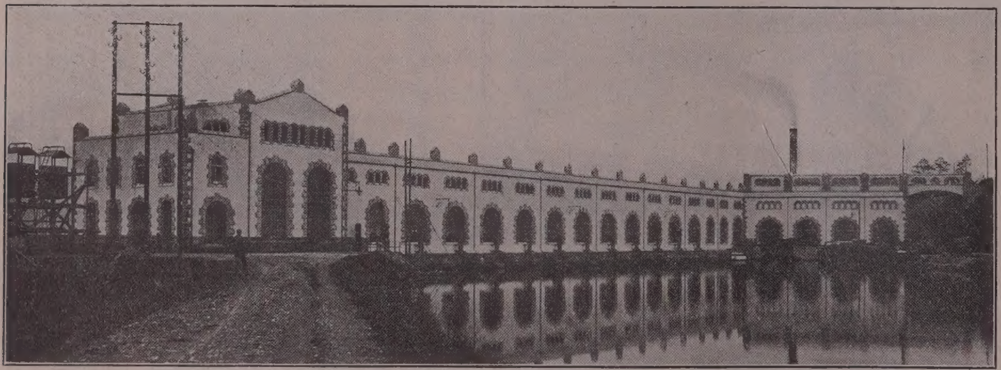
Generators.—All generators, both for hydraulic as well as steam turbines, are three-phase, 8000-volt, 50-cycles machines. The eleven generators of the hydraulic plant are of the vertical type, making 66.6 r.p.m., while the two turbo-generators make 1,500 r.p.m. The latter generators have their own exciters mounted directly on their shafts. For excitation of the hydro-electric units there are two vertical hydro-electric units, each of 400 hp., 150 volts. These exciter units are located near the switchroom.

Transformers.—For supplying the various motors of the plant, as required for operating sluice gates, condenser pumps, air compressors, traveling cranes and for repair shop use and so forth, there are installed four transformers for stepping the current from 8000 to 250 volt; two of these transformers have a capacity of 80 kw., one of 40 kw. and one of 20 kw.

There are also in the basement of the switchroom seven three-phase step-up transformers, from 8,000 to 27,000 volts, each having a capacity of 2,000 kw. These oil transformers are of the water-cooling type, the cooling water being supplied from the headrace.

Busbars and Switchboards.—All leads from the generators to the switchboard are run through the basement on porcelain insulators mounted on structural-steel frames. The leads from the generators of the hydraulic turbines are bare and are arranged on two sides of a tunnel separated by a wire netting partition so that, in case of repairs or inspection, one side is dead while the other side is alive. The leads from the steam turbine generators are three, vein lead and iron-bandaged cables.

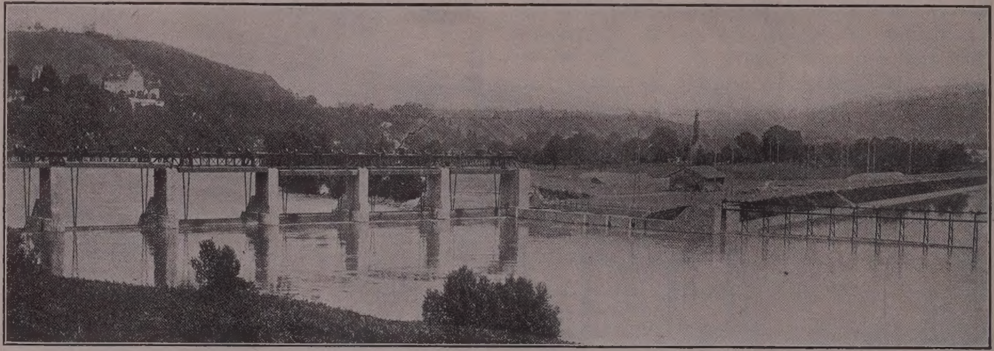
Because of the great number of individual prime movers, and in order to give flexibility to the wiring system, there are two separate busbar ring systems, one receiving the 8,000-volt current from the generators and the other receiving current of 27,000 volts from the step-up transformers. These busbars are distinguished by white and black busbars, respectively. As all generators are 8,000-volt machines, part of this current is distributed to consumers within a radius of 12 miles, while the 27,000-volt current is exclusively used for long-distance transmission.

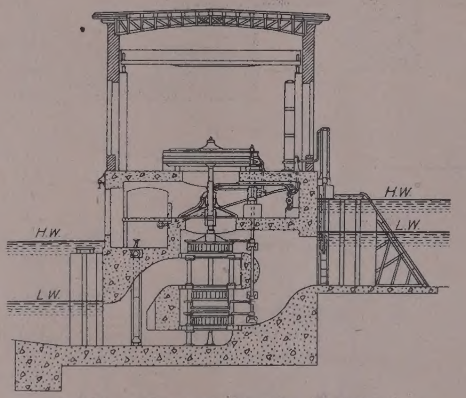

The Combined Station Building from the Upstream Side.

The installation of the steam turbines was also an important factor in connection with supplying the demand for current at a long distance. The wiring system of the station is divided into two complete sections. One part of the turbines may feed the 8,000-volt busbars, while the other part of the turbines may feed, through the step-up transformers, the 27,000-volt busbars; or all generators may be thrown either on the 8,000-volt (white) busbars or on the 27,000-volt (black) busbars.

The busbar systems are well provided with double-throw and sectionalizing switches. Both the 8,000-volt and 27,000-volt switches are of the remote-control type of oil switches. The 27,000-volt busbars are provided with two and the 8,000-volt busbars with one water-flow apparatus for protection against overloads.

The switchroom is composed of a basement containing the generator leads and the transformers, separated by a partition wall; a main floor containing the generator switches, 8,000-volt busbars and the 27,000-volt busbars; and an upper floor, from which the generator room can be observed. This upper floor contains the controlling benches and switchboards. Here are also located the feeder switches and the transformer switches. From here the outgoing feeders leave the building.


Head-gates at the Bend in the River.



Cross-section of Station Building.

For protection of the outgoing feeders Horn lightning arresters are installed. These arresters are separated from each other by marble slabs.

The entire electrical equipment was installed by the Brown-Boveri Co., Baden, Switzerland.

A Small Gasoline Car has been devised by Mr. H. W. Jacobs, assistant superintendent of motive power at the Atchison, Topeka & Santa Fé Railway, for use in driving screw spikes. The car is equipped with a small gasoline engine which will drive at the rate of about 15 miles an hour. At the place where the spikes are being driven, the engine is employed by attaching flexible shafts to it in such a way that the tools for boring the holes and for screwing down the spikes can be driven very readily.

The Washington Street Tunnel of the Boston Subway System.

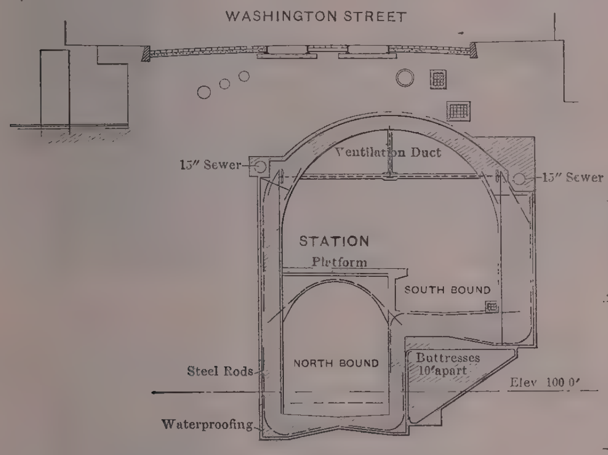
The Washington Street Tunnel, forming part of the Boston subway system and constructed by the Boston Transit Commission, extends through the business district of the city from Ash and Nassau Streets to the Haymarket Square station of the present subway, a distance of about 6,000 ft. The work of construction was started in the fall of 1904, and at the present time the main structure is completed, only a few of the entrances and exits remaining to be finished. The tunnel is double-tracked throughout and will carry the elevated trains which now run in the Tremont Street subway, thus allowing the latter to be used exclusively by surface cars.

On account of the many difficulties encountered, due to the narrowness of the street, the proximity of high and heavy buildings, and the limited room for station platforms, quite a number of different sections have been used in constructing the tunnel. In a number of sections a steel I-beam roof, filled in with concrete, is used, while there is a considerable length built with two-arched passages, separated by a center wall of steel and concrete. The arrangement of stations offered a series of difficult problems, and the adopted designs are naturally interesting. All of the work has been described in the reports of the chief engineer of the Boston Transit Commission, from which these notes have been taken.

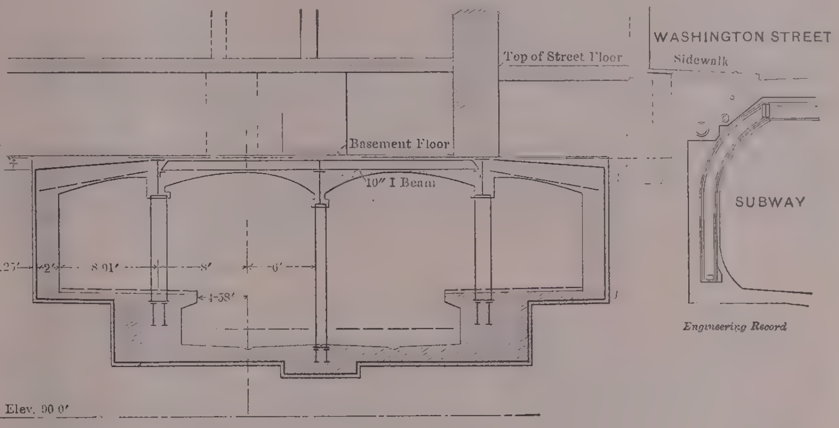
Both tracks in the tunnel are practically on the same grade, with the exception of a considerable difference at the Milk Street station. The maximum gradient is 5.5 per cent., but, since it is used only as a down grade, cannot be considered a governing grade. Next in steepness come the 5 per cent. inclines at both ends of the tunnel. The maximum depth of rail below street level is 41 ft., this being on the northbound track at School Street, and the maximum depth below low water of Boston harbor is 16 ft. at the point where the new tunnel is carried under the present subway. Of the whole length of the tunnel, 40 per cent. will be level, 7 per cent. will have a grade of less than 1 per cent.; 22 per cent. a grade 2 per cent.; 13 per cent. will have grades from 3 to 4 per cent., and about 18 per cent. of the tunnel a grade of 5 per cent. Fifty per cent. of the entire length will be straight; 33 per cent. will have a curvature, with a 5,000-ft. radius; 2 per cent. a 1,800-ft. radius, and 15 per cent. a 500-ft. radius.

For the purposes of construction the tunnel is divided into ten sections, numbered consecutively from south to north. Section 1 lies entirely beneath buildings, and, since it is anticipated that the present structures may eventually be replaced with taller and heavier ones, the tunnel walls and the roof have been very strongly built. The walls and inverts are of reinforced concrete and the roof of steel I-beams imbedded in concrete and supported on the side walls and on a row of center columns. These beams vary, in accordance with the load to be carried, from 12 to 24 in. in depth and are spaced from 1 to 4 ft. apart. The building foundations were supported on steel I-beams during construction and then pinned up on the completed roof with brick masonry.

In Section 2 a number of different designs are used, the greater part, however, consisting of a reinforced-concrete invert and an easterly wall of similar construction, although the westerly wall consists of steel columns on 5-ft. centers surrounded with concrete. Two lines of center columns carry girders extending longitudinally with the tunnel, the roof beams extending across the tunnel and resting on the side walls and these girders. Between these beams, which are 5 ft. apart, concrete jack arches are turned. The tunnel walls in this section for a considerable distance were horizontally within a few inches of and vertically about 10 ft. deeper than the foundations of the adjoining buildings. After reaching the depth of these foundations excavation was carried on generally in pockets 6 ft. in length, the side wall being erected therein before the intermediate pockets were excavated. Even with this method a slight settlement of one of the buildings occurred, and to safeguard against further trouble in the difficult section the buildings were supported by spur-shores before operations were begun. The foundations were then under-run in pockets about 2 ft. wide and strengthened by a concrete base about 18 in. thick, containing 6-in. I-beams, this process being continued until the whole foundation had been strengthened. In that part, however, where the side walls did not come nearer than 8 ft. to the building walls the length of the pockets excavated was about 16 ft. After the side walls had been carried up the core was in some cases completely excavated before placing the roof, and in others the street was excavated only to a depth sufficient to allow the roof to be set in position and finished from side wall to side wall. The core was then excavated underneath, and the earth taken in cars to a shaft and hoisted to the surface. In Section 4 there is a portion of the tunnel of an arched section, spanning the two tracks and built in reinforced concrete, the clear distance between the side walls being about 25.3 ft.



Section at Milk Street Station.



Section Under Buildings Adjacent to Subway.

In Section 5 occurs one of the most interesting designs in the whole line of the tunnel. Going northward on leaving the Summer Street station, the northbound track descends rapidly, reaching a maximum depth of 15 ft. below the southbound track and allowing the Milk Street station platform for the latter track to be built over the northbound line. A platform 14 ft. wide is thus obtained without increasing the width of the regular tunnel section. This design is shown in an accompanying illustration. At this point no provision is made for a platform for northbound trains, and accordingly a 12-ft. passageway has been built to connect with the State Street station. In this section an interesting piece of underpinning was necessary on the Old South Meeting House and the Old South Building, which was described in The Engineering Record of June 15, 1907.

Section 7 is principally interesting, on account of its depth and its position with relation to important buildings, especially to the Ames Building. The latter has a height of over 200 ft. above the earth, on which its foundations rest. It is not a steel-frame building, although its floors are made of steel and masonry. The street walls are of stone, with brick backing, and are so thick as to bring the weight on the underlying earth as great, probably, as would be given by a modern steel building, if the conditions remained the same, having a height of over 280 ft. The alignment of the tunnel and the need of a passenger station in this vicinity required the westerly wall of the tunnel at the Ames Building to coincide substantially with the westerly building line of the street. The bottom of the tunnel is 28 ft. below the foundations of the building and 48 ft. below the sidewalk level. The foundations of the building, however, project into the street practically the whole width of the sidewalk. Consequently, unless the encroaching foundations should be removed, the tunnel would have to be built under them, and a considerable portion of the weight of the building would rest on the top of the tunnel. The conditions at this point are indicated in the accompanying drawing, the cross-section shown being taken not far from the middle of the building. South of this the foundation footings project to a greater and to the north of this section to a less distance over the tunnel than is shown. It was first suggested that the encroaching foundations be removed, but after some discussion it was decided to allow them to remain as shown.

A question very much debated was whether the whole area of the foundation supporting the wall should receive a new masonry support to be carried down to the bottom of the subway excavation, or whether only so much excavation should be made as was necessary for the displacement of the subway. An objection to the latter plan was that even with great care and skill, some of the earth to the west of the subway underlying and supporting the main portions of the street walls of the building might be disturbed. If the former plan was adopted, however, the earth lying still farther west and underlying the foundation masonry in the first row of piers might be disturbed. Mr. John E. Cheney, representing the owners of the Ames Building, strongly favored the latter plan, and accordingly so much of the building as was formerly supported within the street lines were supported on top of the tunnel.

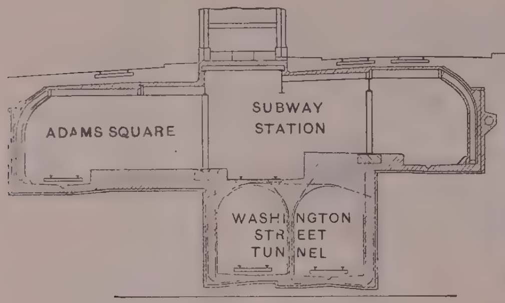
In furtherance of this plan it was at first proposed to make the westerly wall of the tunnel a row of metal or other pipes, to be forced down by jacks reacting upward against the foundations of the building, these pipes being about 3 ft. in diameter and touching each other. For various reasons, however, this idea was abandoned, and details were worked out which did not embody any novel feature of this plan. The westerly wall was formed of a series of hollow piers, each one being begun at the top, that is to say, immediately under the foundation, and extended downward step by step to the bottom of the tunnel wall. The piers were made hollow in their earlier stages so that excavation could be carried on inside of them, and for the further reason that it was necessary to unite as a monolith the reinforced masonry of the arch and invert with the masonry which would finally fill the hollow piers and constitute a large part of the westerly wall of the tunnel. The details by which this work were carried out are as follows:

A trench was first excavated along the front of the building to the bottom of the foundation. A drift about 4 ft. wide and 4 ft. high was then driven under the foundation at right-angles to the trench to the back of the proposed tunnel wall. A row of jacks was placed on each side of this drift to make up as far as possible for the supporting power of the excavated earth. At the farther end of this drift on the line of the tunnel wall a vertical rectangular shaft, 3 ft. by 3 ft. 9 in. in cross-section, was driven down to about 3 ft. below the grade of the bottom of the tunnel invert. As the shaft was driven its walls were made of concrete slabs reinforced with imbedded steel angles and rods, forming a hollow pier. The slabs were fastened together vertically and horizontally by splicing angles bolted in the inside corners of the shaft. Steel foot plates were driven out from the interior of the bottom of the pier so as to project 9 in. beyond the outer edges of the shaft lining at right angles to the tunnel wall, temporarily increasing the footing area until additional supporting area was supplied by the construction of the tunnel invert. After plugging the bottom of the pier with about 3 ft. of concrete the proper portion of the load of the building was transferred to the pier by driving steel wedges between the bottom of the building foundations and steel I-beams imbedded on top of the pier walls or lining. The wedges were so placed that the load was carried through the transverse walls and the back wall of each pier, leaving the wall on the tunnel side unloaded, as the method used involved taking out some of the face slabs, as stated later on.

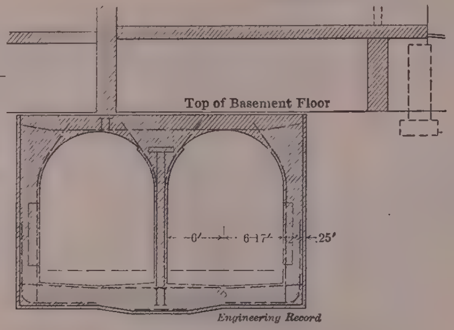
As soon as the first hollow pier was completed and the proper load transferred to the footing a parallel drift was dug, and a second pier touching the first was built in the same manner. This process was continued, forming a cellular wall 3 ft. thick. All void spaces around and between the piers were filled with grout. Thirty-four of these hollow piers were put down, 25 of which were directly under the building foundations. For about one-third of the piers, where the ground was soft, rectangular steel shields about 3 ft. deep were used. These were jacked down as the excavation proceeded, the concrete slabs being bolted in place behind them in a manner similar to that employed in ordinary shield tunneling. The shields were left in place at the bottom of the pier. After the entire combined underpining and tunnel wall was in place the westerly barrel of the tunnel was built in sections from 7 to 8 ft. long. Some of the concrete slabs were removed from the face of the underpinning wall, where the latter was joined by the tunnel arch and invert, thus allowing the steel reinforcing rods from the arch and invert to be carried through the opening into the hollow piers. These piers were filled with concrete when placing the concrete for the inverts and arch, thus making the pier filling monolithic with the rest of the tunnel section, as shown in the figure.

This method, with some modifications to suit the different conditions, was later used to underpin the Washington Street front of the Devonshire Building, on the opposite side of the street. Owing to the unusual problems involved and the consequent desirability of being able to alter the plans, or vary methods at any stage of the work, the section was built almost entirely by day labor under the direction of the engineering department of the Transit Commission.

In that portion of the tunnel known in construction as Section 8, a distance of 400 ft. in Adams Square lies in whole or in part underneath the old subway. In order to depress the tunnel as little as practicable, its roof and the floor of the subway where the two are in common are heavily reinforced with steel made as thin as is consistent with the requisite strength. The thickness from the base of the rail of the subway to the intrados of the arch underneath is in some cases only a foot. Work under the old subway was carried on by excavating drifts about 8 ft. wide on each side of the tunnel structure. A lower drift was driven first, followed by a drift immediately over and extending to the under side of the old subway. Back walls 12 in. thick are carried up against the outer side of the drift to support the subway, while the main side walls are carried up to the springing line. The central core was removed in short longitudinal sections, the building of the invert, center wall and roof following thereafter in the order named.



Section Under Present Subway.



Section Under Buildings.

Section 10 consisted of the incline in which the cars will rise from beneath the surface at the north end of the tunnel to the elevated railway structure. The construction of this section adjoining the original subway necessitated the removal of portions of the walls and roof of the latter. The new structure is essentially a widening of the subway by the construction of a new wall, an average distance of about 40 ft. easterly from the subway wall. Steel columns, ranging about 27 ft. westerly of the new wall, directly support transverse beams extending from the new wall, and jack arches between these form the main roof of the structure. The remaining strip of roof is formed by jack-arches between transverse girders having their westerly ends permanently connected with the steel roof beams of the subway. The general method was first to excavate for and build the easterly wall, then to dig a longitudinal trench for the steel columns. After these were erected excavations were carried sufficiently deep to place the roof beams in position. The operations of riveting, concreting the roof, taking out the core and constructing the invert followed in succession. At the northerly end of the section for a distance of about 60 ft. the line of new columns will not be placed until just before the traffic is to be diverted from the subway into the tunnel, the subway columns serving as supports in the meantime.

Incidental to the construction of the tunnel has been the relocation of pipes, sewers and underground conduits. Temporary connections were in all cases made so as to give uninterrupted service while operations were in progress. The permanent locations assigned the various underground facilities conform wherever possible to plans made by the Transit Commission, the general arrangement being as follows: Sewers are built on either side of the tunnel; electric conduits are laid deep in the gutter, passing below the catch basin; the electric lighting conduits are on the west, and those for the telephones on the east side of the street; gas pipes are laid outside of and adjoining the street railway tracks, and water pipes are laid between the gas pipes and telephone conduits, leaving a space between the conduits and the water pipes for service gates and manholes. A clear space is reserved at the proper depth for present and future fire-service connections to all buildings. The water pipes are laid as far as possible from the street railway tracks to avoid danger from electrolysis, and many of the bends and complicated connections on the old pipes have been eliminated in the new lines. The pipes, sewers and conduits as laid occupy practically all of the available space at most of the street intersections, and little or no space is available for future additional pipes, except underneath the tunnel.

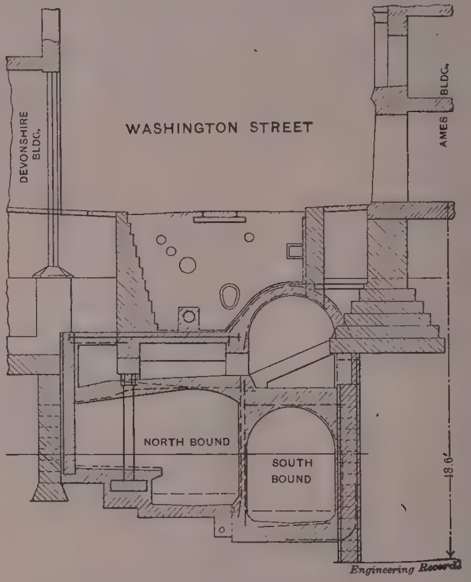
Practically all of the work of construction, and particularly so in the busiest part of Washington Street, has been carried on at night and on Sundays, where occupation of the surface of the street was necessary. During the day, it was generally possible to carry on work beneath the surface and so make the operations continuous. The disturbance of the street surface during business hours has been restricted to small openings near the curbs, 100 ft. apart, for the placing of concrete and passing building and bracing materials in and out of the trenches. In the less-congested section excavation has been permitted in the day, but the contractor has been limited to the use of spaces not exceeding 30 ft. in length by 10 ft. in width and at least 100 ft. apart. In some isolated cases one-third of the width of the sidewalk was used for construction purposes. The running of street cars in the day was not interfered with, unless for some special emergency and then for a short time only.

During the night and on Sundays the contractors were allowed to use as much of the street surface as necessary, providing that sufficient sidewalk accommodation was given pedestrians and room left for fire engines to pass through and into adjoining streets. Street cars have in the night frequently been diverted to neighboring streets.

While the operations of building the tunnel were going on the surface of the street was kept covered with timber bridging flush with the pavements for the maintenance of street traffic, the earth being taken out and materials passed in and out of the trenches through the small hatchways near the curbs, to which reference has already been made.

The tunnel having been completed, the street was back-filled and paved temporarily on a gravel base, this paving being frequently renewed until the final pavements were put in after the settlement of the underlying earth had presumably ceased. As far as conditions permitted, the various municipal departments of the public service corporations relaid their pipes and conduits at the side of and over the roof of the tunnel before the back-filling took place.

Practically all of the stairways and station entrances and exits are on what was formerly private property, all of which has been taken over by the Transit Commission. The same is true of all but one of the fan chambers and the exits for vitiated air to be removed from the tunnel.



Section at Ames Building.

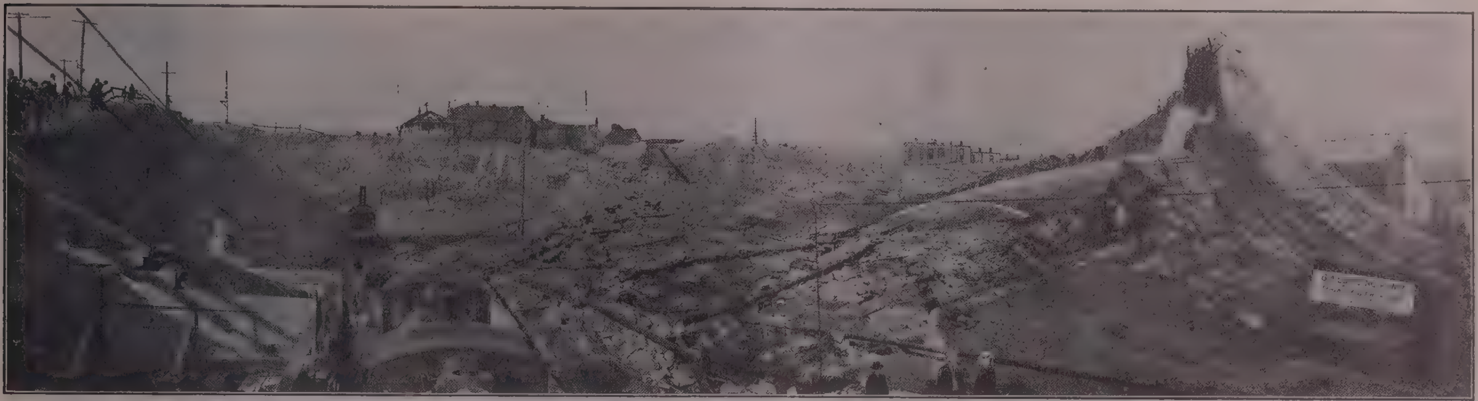
The ventilation of the tunnel is effected by admitting fresh air at the stations and at the portals, and withdrawing it from the tunnel at points midway between them. The air in leaving the tunnel at intermediate points will pass to fan chambers through specially constructed ducts, in some places underneath and in others above the tunnel, having a minimum cross-sectional area of about 40 sq. ft. and a length of from 270 to 430 ft. There will be room in each fan chamber for two single-inlet centrifugal fans, each with a capacity of 20,000 cu. ft., or more, per minute, giving an average velocity of air in the tunnel of upwards of 1 ft. per second, equivalent to changing the air in each section three or more times per hour.

The engineering features of the Washington Street tunnel have been designed by the engineering department of the Boston Transit Commission, Mr. H. A. Carson, chief engineer.

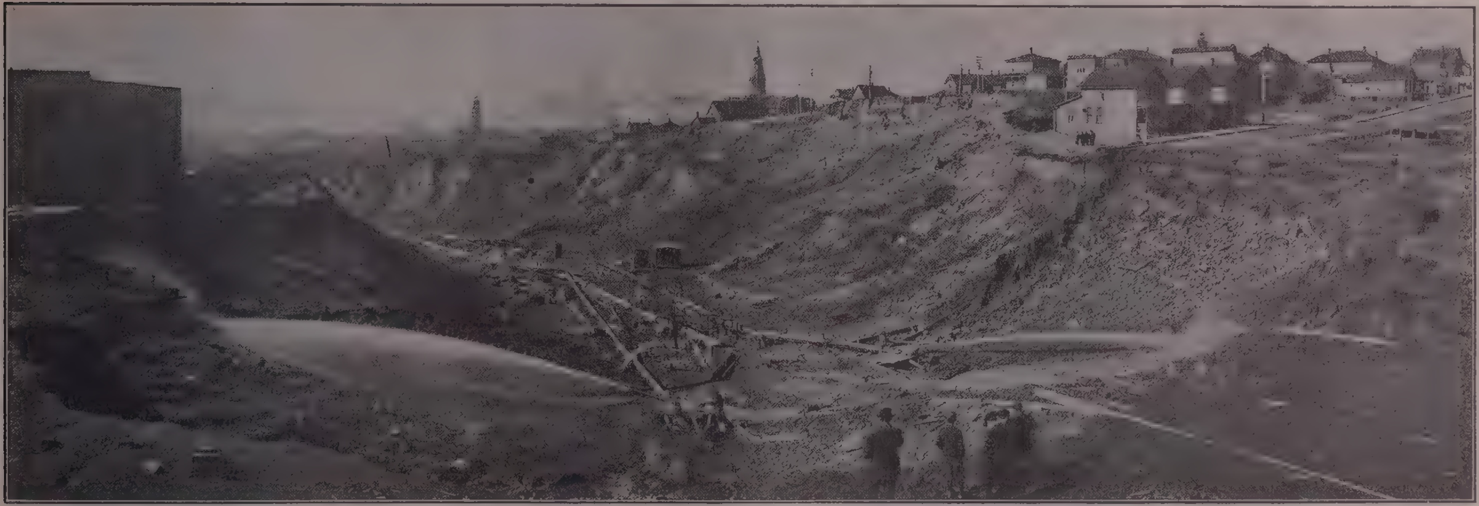
A Blowing Well owned by Mr. J. B. Murphy, near Raymondville, Mo., is described in a recent bulletin by Mr. Edwin M. Shepard, issued by the U. S. Geological Survey. This well, which is on a hill, was drilled in 1899 to a depth of 187 ft. Soft water was struck at the bottom and rose 7 ft. in the well. In a dry time, particularly in the winter, the well becomes dry. In drilling it a cave 3 ft. high was struck at a depth of 100 ft. When the well is dry, if there is a long prevailing wind from the north, a current of air rushes from the pipe strong enough to blow the cap from the tubing.

The Re-grading of Seattle, Washington.—II.

Jackson St. Re-grade.—Adjoining on the north the district included in the Dearborn St. improvement is an area covering sixty-eight city blocks, known as the Jackson St. re-grade, in which over 3,000,000 cu. yd. of materials are being removed hydraulically under contract by Messrs. Lewis & Wiley, Inc. The object of the work in progress in this district is to cut the hill so the cross-town streets, which now ascend to the summit of it from the Sound side on undulating grades varying from 6 to 18 per cent. and then go down into Rainier Valley on equally or more objectionable grades, will have continuously ascending grades from the Sound side to Twelfth Ave. This continuous grade will also be much flatter in each case than those which now exist. At the same time, the grades of the north and south streets will be greatly improved from Dearborn St. up to Jackson St. The limit of the district on the north is marked by Yesler Way, one of the present principal cross-town streets leading from the central business district into that section, which street now has an undulating grade with a maximum rate of 15 per cent. The hill rises toward the north so rapidly from the Jackson St. district, and is covered with so many permanent improvements that it is impracticable to attempt to greatly reduce the grades on Yesler Way. The latter will, however, be straightened out to a uniform grade of 10.5 per cent. by a series of heavy cuts and some fills. The area to the north of Yesler Way is on the top and sides of the hill in the rear of the business district, and is to be improved as has been explained.



First 1,500,000 cubic yards of Excavation in Denny Hill Approaching Completion.



Junction of Two Pits in Jackson Street Re-grade after the Removal of 300,000 cubic yards of Material.

The work thus far done on the Jackson St. re-grade by Messrs. Lewis & Wiley, Inc., has been handled under practically the same conditions as those encountered in making the first hydraulic cut in Beacon Hill. A pumping station that was formerly used to deliver water from Lake Washington into the distribution mains of the city was rented by the contractors to pump water enough to a reservoir on Beacon Hill to make up the deficiency of the amount required over the surplus quantity obtainable from the municipal supply. The total quantity used for the hydraulic giants was delivered to the cut in a 22-in. wood-stave pipe, with a resultant pressure of about 85 lb. at the nozzle of the giants. Two branches were extended from this main pipe line to two separate pits, in each of which pits two of the giants were operated. These pits were started at separate points, one at the base of the hill, where the cut and fill intersect at an elevation of 50 ft. above high tide, and the other at the southerly limits of the district, where the new grade and the slope of the cut intersect. These pits were then carried ahead at the new grade with a working face varying from 10 to 80 ft. One of the accompanying illustrations shows the two pits after they had been brought together, with approximately 300,000 cu. yd. of material, or 10 per cent. of the whole amount to be excavated under this contract, removed from them. From this illustration the magnitude of the operations that have been undertaken can be somewhat appreciated.

The hydraulic apparatus and the methods used by Messrs. Lewis & Wiley, Inc., have been developed by extensive experience in handling hydraulic operations under similar conditions. Each giant is mounted at the end of the branch line supplying it with water, on a ball-and-socket joint, having a hemispherical gasket that permits the giant to be rotated through a full circle. These joints are also such that the giant will remain in any position in which it is placed, thus greatly reducing the danger to the operator when working with high pressures. At the same time, the giant is equipped with a lever so that it can be handled readily by one man under any pressures. Cast-iron nozzle tips designed to deliver a solid stream of water are used. The nozzle opening varies from 2.5 to 3.75 in. in diameter, depending on the character of the materials against which the giants are being played, and other conditions.

The face of the cut is maintained as nearly vertical as possible, and is reduced by being undermined, wherever it is feasible to work in that manner. Some of the blue clay and conglomerate requires light blasting to loosen it at the face of the work, but most of it can be started with a stream from a giant. When the clay breaks out in large lumps, or when boulders are encountered, the overlying sandy soil and loam are used as a lubricant to carry the larger masses to the flumes. After the clay is once started in this manner it appears to grind up rapidly until it is soon in pieces ranging in size from particles as large as a pea to those having a diameter of 6 in. Boulders of upwards of 12 in. in diameter will also be carried by the stream from the giant, but stones larger than 6 in. in the greatest dimension are not permitted to enter the closed pipes on account of the danger of blocking the latter.

Races are not required to deliver the materials from the cutting faces to the flumes when the work is handled in the manner described. Guide boards are placed at intervals where irregular channels start to form in the bottom of the pit between the working face and the end of the flume. One man is employed to each giant in operation to keep up these boards and to remove from the stream going to the flume roots or similar material that would be liable to choke the flume. A rough, temporary penstock of boards is built to direct the water into the end of the closed pipe, but for flumes nothing of this sort is necessary. A grizzly of inclined iron bars is placed in the penstocks of the closed pipes to intercept large stones and lumps of material, which are removed or reduced by a man in attendance at that point. Under ordinary conditions five men can thus operate two giants where no blasting is necessary, the sluicing being generally carried on continuously with three 8-hr. shifts. With two giants in regular service in a pit, making a cut in materials similar to those thus far encountered, an average of about 3,000 cu. yd. of materials is removed every 24 hr.

A pumping station designed specially to deliver salt water for the sluicing purposes necessary in connection with this contract, has recently been installed on the water-front, 6,000 ft. from the center of gravity of the cut to be made. This station was designed by Messrs. McAllaster & Bennett, consulting engineers, of Seattle, and built under their direction as engineers to the contractors. The pumping equipment consists of two pairs of 10-in. five-stage Worthington turbine pumps, each pair having a normal capacity of 6,000,000 gal. per 24 hr., when delivering against a head of 375 ft. Each pair of pumps is driven by a 650-h.p. synchronous, 2,000-volt alternating-current Westinghouse induction motor. One of the most significant features of the installation is the fact that the four pumps and their motors, with a combined capacity of 12,000,000 gal. per day, against a head of 375 ft., are in a small wooden building, 31 ft. 4 in. x 37 ft. 2 in. in plan, that stands on a timber pile footing some 200 ft. from the shore line at low tide.

The variation of the tide at the site of the station is as much as 18 ft., so the pumps had to be installed to meet this condition. The piles of the footing were capped with 6 x 12-in. timbers, on which was placed a grillage of joists, spaced according to the load to be carried. These joists were covered with a double floor, consisting of a lower layer of 1 x 3½-in. matched flooring and a top layer of 3 x 6-in. plank. This floor was placed at normal high-tide level, which is exceeded a few times in June and December of each year as much as 2 ft., in order that the pumps could be operated at minimum low tide. The sides of the building were built tight up to 2.5 ft. above the normal high-tide level by using 2 x 4-in. timbers and caulking the joints between these timbers. An intermediate tight bulkhead, 2 ft. high, was also built along one side of the space occupied by the pumps and motors to separate the latter from the balance of the building to that height. The space outside of this bulkhead has an opening in the floor that permits water to enter, but this opening can be closed with a plug. When the tide rises excessively water is allowed to enter the opening until the level of the water in the main compartment rises to notches cut in the top of the bulkhead along the pump pit and flows over into the latter. These notches are placed at a height below which there is in no danger of the difference in flotation distorting the building. After the water starts to flow through the notches a ¾-in. connection on the suction of each pump can be opened and the level of the water in the pit kept down until the tide falls again, since the water would have to reach a depth of over 2 ft. around the motors before it would become dangerous.

The four pumps and the two motors are grouped so they actually occupy a space 14 x 24 ft. in plan. The two pumps of each pair are on opposite sides of the motor which drives them and are direct-connected to the latter by a flexible coupling, each unit operating at 690 r.p.m. The pumps each have a separate end suction and separate overhead discharges, the latter all delivering to one pipe line. The steel shafts of the pumps are encased in bronze where they are exposed within the pump casing. The runners and diffusion vanes are also built of bronze as a protection against the action of the salt water.

Each unit of a motor and two pumps has six main bearings, two for each pump and two for the motor. A thrust bearing of the standard babbitted type with six collars is also placed at one end of the shaft of each pump unit to take any unbalanced thrust that may occur. These bearings are enclosed in a case filled with oil, which is carried up on the shaft by loose rings riding on the latter. They are cooled by water circulated through them from a connection to the discharge of the pump in each case.

Electric power is delivered to the station at about 27,000 volts, from which voltage it is stepped down to the operating voltage of 2,000 volts by transformers outside the building. In order to reduce the heavy load that would otherwise be brought on the transmission line, the motors are each started by means of ten solenoid switches arranged in series and controlled by a master switch. The arrangement of this starting system is exactly similar to the standard Westinghouse equipment installed on single-phase electric locomotives.

A 24-in. machine-banded wood-stave pipe line, 6,000 ft. long, has been laid from the pumping station to the excavation in which work is now in progress. This pipe was built by the Pacific Coast Pipe Co., of Ballard, Wash., and is designed for a working pressure of 375 ft. It is made in lengths of from 8 to 16 ft., with wood-stave collars, 8 in. long, around the joints between the lengths. The pipe staves are of Oregon fir, 1⅝ to 1¾ in. thick, and are bound together with No. 1 galvanized-iron wire, spaced 9/16 in. apart on centers. The collars each have five individual ½-in. round-iron bands with upset ends.

Grading on Fourth Avenue, Showing Character of Structures Affected.

The pipe line has to be laid under two heavy traffic streets, two street railway tracks, several railroad tracks, and then across the tide flats in order to reach the hill. Four branch connections are taken from it within the limits of the area to be graded, while the main line is extended beyond these connections as a 16-in. pipe, from which two branches are taken. The main is also located through the two pits that have been opened on the edge of the main cut, so the latter may be attacked with two giants from each of the branch connections that are provided.

Part of the material removed from the Jackson St. re-grade is being carried over a mile to fill a section of the tide lands along the portion of First Ave. that has been completed across these lands. The remainder is utilized for filling in the tide lands closer to the cut. The material delivered to the tide flats is transported in a 20-in. wood-stave pipe line extending across the intervening low area. The material furnished to the adjacent low lands is carried in a 2 x 2-ft. flume, about 2,000 ft. in length. Closed pipe is, of course, more advantageous for handling the spoil from the hydraulic-mining operations, specially over long distances, since it does not have to be laid to the hydraulic grade, and materials are transported in a closed pipe under pressure at much flatter grades than is possible in flumes. A 2 per cent. grade, however, has been found to be the minimum at which a pipe line can be satisfactorily operated, while a flume carrying the same class of materials must have grade of not less than 5 per cent. The limiting maximum grades are different for different materials, being controlled, of course, by the amount of wear in the pipe or flume. Special provisions have been made on this work which practically prevent wear in the pipes and flumes, by using blocks of wood cut across the grain as a lining.

The contractors on the Jackson St. re-grade receive a total of 25 cents per yard for all of the material that is moved. The district and the individual property owners on the hill pay 10 cents per yard to have the material taken out. The contractor receives 15 cents per cubic yard for the material delivered to the tide flats, where measurements are made on the cubical contents of the volume in place, plus 15 per cent. for shrinkage. The contractor is also privileged to deliver the material at such points in the low lands as will best suit his interests, subject to supervision of the city.

Methods in Business District.—The re-grading of First and Second Aves. has been completed from the tide flats through the business district and through Denny Hill, to the north of that district, in a distance of about a mile and a half. In fact, these two streets have been at the present grades to the foot of Denny Hill for several years. Third Ave. has been cut through the hills at the new grade to the foot of Denny Hill during the last three years, and will be extended through that hill by work now under way. Fourth Ave. is being cut down to the grades required by the new plans, from the south end of the hill back to the business district to the north end of this hill, and will be carried through Denny Hill by the work now in progress. Contracts for the reduction of Fifth Ave. to the proposed grades will be awarded during this year. In all of this work through and adjacent to the business district, the areas along the streets have been, or are being, lowered to the grade of the latter. The contiguous areas are also being taken down to conform to the general plan.

Most of the excavation thus far completed, or now in progress, in this section, has been made with steam shovels and hauled out to the tide flats in cars running on tracks laid in the streets. The plant and methods employed in handling the work now in progress on Fourth Ave., where Mr. C. J. Erickson has the contract for the excavation, are typical of those employed on the re-grading that has been done under similar conditions. The improvements along this street include a number of large permanent apartment hotels, club buildings and so forth, which preclude the possibility of using hydraulic methods for excavating. These buildings for the most part extend out to the original street line, and as the width of the street is to be increased from 66 ft. to 84 ft., by taking 9 ft. from the property on each side, several of these large structures will have to be cut back to that extent. Smaller buildings in this section are generally removed in advance of the excavation. This street and Third Ave. also both cross two important east and west cable-operated street-railway lines which have to be maintained in service while the re-grading is in progress, although cuts of 20 to 32 ft. are required at the street intersections, and the connecting streets are also cut down very materially. Similar work has also been done in maintaining street-railway tracks in many other instances.

Trestle into Puget Sound for Flume from First Denny Hill Cut.

The excavation on Fourth Ave. was started at the new grade at the end of the street toward the tide flats and then carried directly ahead. Two steam shovels, a Model 60 Marion and a Thew, handle the material into 3-yd. dump cars. The shovels are operated in the cut about the same as they would be in a railroad cut, the grades on the running tracks being kept as low as possible and the shovels being worked against the most desirable height of face that can be obtained. The dump cars are operated in trains by light locomotives which haul them from the end of the cut on an overhead trestle that extends out on the tide flats at about the new grade obtained there. The material is used for filling in those flats on both sides of the trestle.

Denny Hill Re-grade.—The reduction of Denny Hill has been one of the most spectacular, and at the same time one of the most beneficial of the sections of the re-grade that have been undertaken. The first contract in connection with this work included the removal of 1,500,000 cu. yd. of material in an area covering two city blocks. The completion of this contract will reduce a butte that rose to a height of 315 ft. above the Sound and 142 ft. above the former end of First and Second Aves., at the south end of this butte, so that the level of the entire area will be such that it can be reached on easy grades from the business district. The balance of Denny Hill, which sloped away on steep grades in all directions from the high butte, is also to be reduced under a recently awarded contract that includes the removal of 5,000,000 cu. yd. of material. The former limitations to the extension of the business district northward will thus be entirely overcome. An area in the rear of Denny Hill, that was formerly not only inaccessible, but was also unsuited for business purposes, is being raised and low hills at the rear of this area are being graded so that another considerable district will in this manner also be brought directly into the main business section.

A large hotel building occupied the top of Denny Hill, and the sides of the latter were also quite closely built up with a good class of residences. This hotel and all of the buildings adjacent to it were destroyed in advance of the work that has been done. The remainder of the buildings and dwellings on the hill will also have to be removed before the contract recently awarded can be carried out, but provisions have been made to this end. The cost of making such a cut as has been undertaken on this hill and the damages incurred by the destruction of the existing improvements on the latter are, of course, very large. At the same time, the resulting increase in the value of the property so completely offsets the expense of the work as to render the undertaking a most profitable one. As an illustration of this result, the case of that part of Second Ave. which has been cut through the hill may be taken. This portion of that street was practically inaccessible before the re-grading was started, but it is now on a grade of 4.9 per cent., and most of the re-graded portion of it has been built up, since the completion of the excavation, with large permanent business buildings. Corresponding results are certain to follow the additional grading of the adjacent areas, as plans have already been made for numerous large buildings in these areas.

Method of Maintaining Street Car Lines during Re-grading.

The contract for the removal of the first 1,500,000 cu. yd. from the top of this hill was awarded to Mr. H. W. Hawley, who sluiced 400,000 cu. yd. of material from the top of the high butte into deep water in the Sound. An additional 700,000 cu. yd. of material were delivered from this cut to the Great Northern R. R. at the foot of the hill. From this point the material was hauled in cars through the double-track tunnel of that railroad under the business section, to be used in filling a part of the terminal site in the tide flats. The remainder of the material included in this contract is being taken out in cars and delivered to the low areas in the rear of the hill by Messrs. Hawley & Lane.

A pumping station was installed on the waterfront at the foot of the hill to supply salt water for the giants used in the sluicing operations. This station contained a 12-in. four-stage Worthington turbine pump direct-connected to a 1,000-h.p. Westinghouse induction motor and a 6-in. two-stage Ogdensburg turbine pump direct-connected to a motor of the same type. The larger pump was operated at 550 r.p.m. and delivered 7,000 gal. of water a minute against a maximum head of 400 ft. The smaller pump was capable of operating against the same head and was driven at 700 r.p.m., at which rate it could deliver 1,500 gal. of water per minute. Two riveted-steel force mains were laid from the station to the cut, a 14-in. pipe for the larger pump and a 9-in. one for the smaller pump. The hydraulic giants were mounted at the end of force mains on deflectors. They were fitted with nozzles having openings varying from 2.5 to 4 in. in diameter, depending on the material encountered.

The top soil on the hill was all sandy loam and clay to varying depths and was readily moved by the giants. Under this top soil was a deep stratum of stiff blue clay containing occasional pockets of boulders and cemented conglomerate that could practically all be moved by the giants, as a pressure of 100 lb. per square inch could be maintained at the nozzles with the pumping equipment installed. Some of the clay and the pockets of conglomerate, however, had to be loosened with light blasts.

A 4 x 6-ft. tunnel was driven from one corner of the cut to the face of the hill rising from the shore line of the Sound, in order to obtain a low outlet for the sluices in which the spoil from the hydraulic operations was carried out into the Sound. This tunnel, which was about 800 ft. long, connected with a trestle that extended over the low ground along the shore line for 1,200 ft. and then out over the water for nearly 1,200 ft. farther to the required depth. The tunnel was driven on a 5 per cent. descending grade from the cut, the trestle being built at the same grade. A sluice, 2 x 2 ft. in cross-section, was laid in the tunnel and on the trestle at this grade. This sluice had double-plank sides, but its bottom was protected against the wearing effect of the materials carried with 6 x 6-in. blocks laid with the grain of the wood normal to the flow. The offshore portion of the trestle was built through water that required piles as long as 120 ft. to construct the bents, the permit from the War Department under which the material was deposited in the Sound requiring that a minimum depth of 40 ft. should remain after the filling had been finished.

The top of Denny Hill was sufficiently high to permit the materials loosened by the giants to flow directly into the sluice. After the hydraulicing had been carried down to a point where the materials would not flow readily, the stream from the small giant was used to carry them to the entrance to the sluice. A steam shovel was also installed later to load the material into the cars below the level from which it could be moved to the sluice with water. A track was laid from the point where the shovel was in operation to a low trestle near the mouth of the flume, so material loaded into the cars could be hauled to this trestle and dumped from the latter into a race leading to the flume. The dirt was moved in this race to the flume by a stream from the small giant.

The 700,000 cu. yd. of material furnished to the Great Northern R. R. was excavated by the steam shovel and loaded into 3½-yd. dump wagons, in which it was hauled on an average about 1,000 ft., to the head of a double-track tramway leading down the side of the hill on a 20 per cent. grade to the railroad tracks. This tramway carried two 7-yd. steel skips, the descending loaded skip pulling the empty skip up the grade. The wagons dumped their loads into a trap, from which the cars were filled, the skips dumping into railroad cars on the tracks below. Ten wagons were capable of serving the shovel under these conditions, as the tramway skips would make a trip each way in about 40 seconds, or as fast as the wagons could reach the trap and dump their loads.

The remainder of the cut which is being hauled out to fill the low area in the rear of Denny Hill is loaded into dump cars by the steam shovel. These cars are operated in trains by light locomotives on tracks on temporary trestles laid to the new grade in the low area, over a mile of these trestles having been built. The fill required to establish the new grade ranges from nothing at the edges of the depression to as much as 28 ft. and necessitates nearly 500,000 cu. yd. of material for the streets alone. The district is quite closely built up with dwellings, small retail establishments and some manufacturing buildings. Some of these structures have been removed, while others have been raised to the new grade on shoring. A considerable number of retaining walls have also been built around private property to hold the street fill until such time as the owners may decide to bring their land up to grade.

The contract for the removal of the additional 5,000,000 cu. yd. of material to be removed from the Denny Hill was awarded to Messrs. Lewis & Wiley, Inc., of Seattle, who sub-let it to Messrs. Grant, Smith & Co. The sub-contractors have arranged to remove the entire hill by hydraulic methods, and to waste the material into the Sound. A pumping station containing the same equipment as the one installed at the lower end of the city by Messrs. Lewis & Wiley, Inc., to supply water for the Jackson St. re-grade, has been erected on the shore of Lake Union to supply water for this work. This station will deliver water against a head of 375 ft. through a wood-stave pipe line, about a mile in length. A tunnel has been driven to carry a sluice from the foot of the cut to a trestle that will extend to deep water in the Sound.

The detail plans for the re-grading are prepared under the direction of Mr. R. H. Thomson, as city engineer. In addition to the preparation of complete engineering plans, every item and detail concerning the method of disposition of every structure in the various districts, and the amount of salvage from each building are carefully investigated before any legal proceedings are undertaken. The contracts are carried on under Mr. Thomson's supervision, the same as any regular local improvement work.

The Aqueduct Embankment on the line of the new Fish Creek supply for Rome, N. Y., will be constructed in a rather unusual manner. The aqueduct has a horseshoe cross section of approximately 3 ft. in width and height. It will be supported on piers 4 ft. wide and 2 ft. thick spaced 6 ft. on centers and connected at the top by full centered arches. The aqueduct will be carried directly on these arches. The piers and the aqueduct will be inside an embankment of the usual type, provided with culverts for the small brooks which are caught. There are several structures of this sort on the aqueduct, the longest being about 150 ft. The new supply has been designed by Messrs. Knight & Hopkins.

The Sangamon River Bridge.

By A. O. Cunningham, Chief Engineer, Wabash R. R.

A new double-track concrete bridge has lately been constructed by the Wabash R. R. over the Sangamon River just east of Decatur, Ill. The necessity for this bridge was caused by the railroad changing its line and grade between the towns of Decatur and Sangamon. Formerly, the track was carried by a steel bridge approached by very sharp curves and heavy grades. As the new alignment contains but two 1 deg. curves and only 0.3 per cent grades, very heavy construction was necessary. The new line crosses the river at an angle which required the bridge to be built on a skew of 45 deg. The bridge consists of four spans of 100 ft. center to center of piers, the clear opening parallel to the tracks at the springing line of the arch being 85 ft. 10 in., and at the bottom of the pier 82 ft. 5¼ in.

The intrados of the arch ring was made in the form of an elipse, the extrados being an arc of a circle. By making the intrados an elipse it was possible to construct the falsework for the arch forms of ribs with a radius of 30 ft. 4¼ in. at right angles to the line of the piers, thus making the falsework construction quite simple.

The Sangamon River Bridge of the Wabash Railroad near Decatur, Illinois.

To overcome the effect of the skew as much as possible, the piers and abutments were so constructed with concrete skew-backs as to give square bearings for the arch ribs instead of skew.

The masonry was built to the top of the skewback and allowed to harden, then each arch ring was turned by working night and day without stopping.

The arch rings are heavily reinforced with 1-in. rods near the inner and outer faces.

The foundation of the bridge is on gravel overlying a strata of very stiff clay. Piles were driven through the gravel into the clay. The piers are carried on reinforced concrete slabs, which not only distribute the load over a large area, but also have a tendency to prevent scouring.

As the cost of ordinary abutments would have been exceedingly large, on account of the height of the structure, a plan was finally evolved which lessened their cost considerably. To prevent scouring of the toe of the high banks, it was decided to use retaining walls 10 ft. high (the height of maximum flood), allowing the fill to rest against them.

All rods used in the structure were 1-in. corrugated bars, supplied by the Expanded Metal & Corrugated Bar Co., St. Louis.

All that part of the concrete where the bars were spaced close together was made of a mixture of 1 part Wabash Portland cement, 2½ sand and 5 gravel. The plain concrete and that in which the bars were spaced 12 in. or more apart was made of a mixture of 1:3:6.

Vertical joints were placed in the spandrel walls, over the center of the piers, and at the skew-back to allow for deflection of the arch rings.

The amount of earth excavation, piling and concrete in the structure was as shown in Table 1.

TABLE 1, AMOUNT.

Earth excavation	8,320 cu. yd.
Piling	36,775 lin. ft.
Foundation slabs for piers	1,300 cu. yd.
Piers proper, with skew-backs	2,270 cu. yd.
Arch rings	2,370 cu. yd.
Spandrel walls of arches	2,180 cu. yd.
Foundations for abutments	1,580 cu. yd.
Abutments above foundations, including slabs and intermediate walls, together with spandrel walls	5,930 cu. yd.
Retaining walls	540 cu. yd.

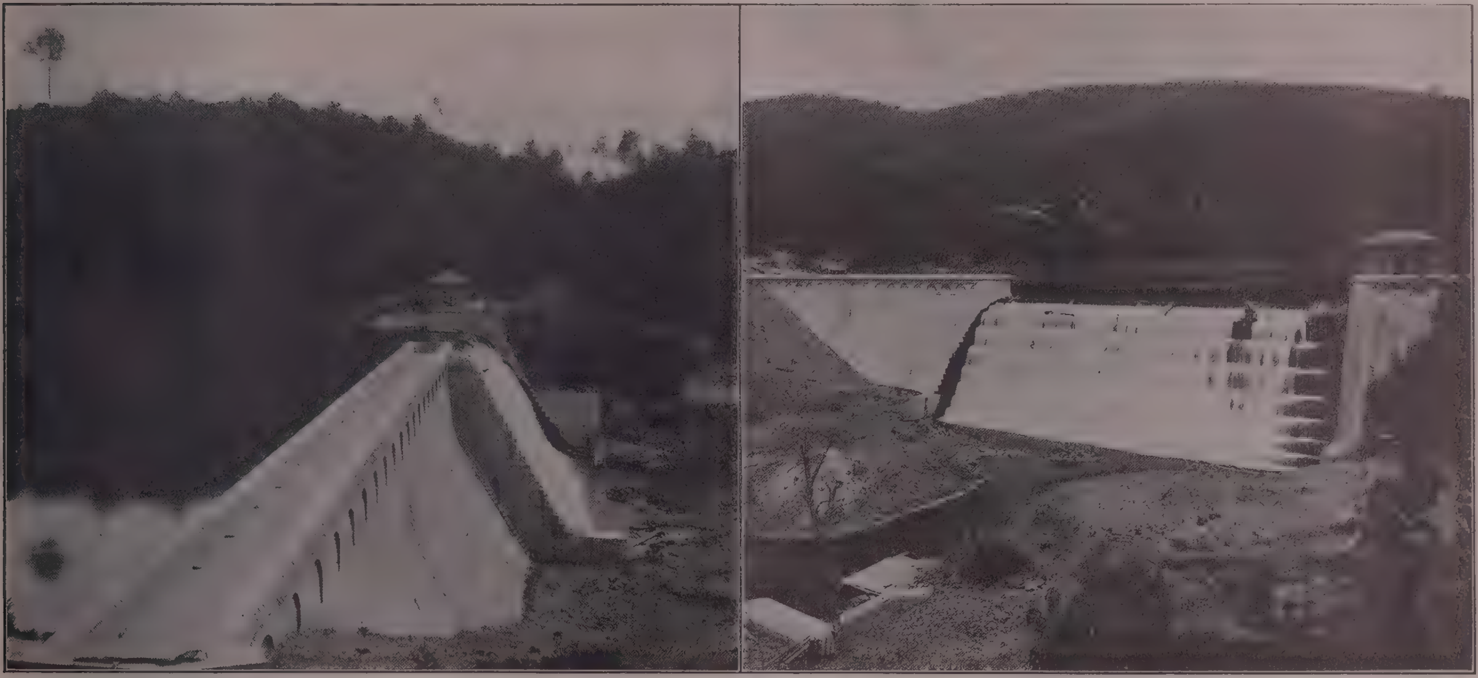
The bridge was designed to carry a dead load consisting of concrete at 150 lb. per cubic foot, earth fill at 100 lb. per cubic foot, and a live load of 9,000 lb. per lin. ft. of track for each track. The permissible unit stress in the concrete was 600 lb. per square inch, and for the rods 12,000 lb. per square inch. The permissible load on the piles was 25 tons per pile.

The contractor for the work was the Wm. P. Carmichael Co., Williamsport, Ind., the falsework and forms being designed by that company. The bridge contains a total of 16,170 cu. yd. of concrete, 215 tons of bars, and cost slightly less than $124,000. The writer designed the structure.

THE METROPOLITAN PAVING COMMITTEE, of London, England, was formed at a conference of representatives of all of the metropolitan boroughs in 1903 in order to collect and classify information regarding the paving materials and methods adopted in London under varied circumstances, in order to make the experience of all the boroughs available to each other. The information supplied to the committee covers almost every recognized description of street paving, method of laying and its cost, details of foundation and sub-soil, life of paving, cost of maintenance, effect of paving disturbance, the use of scarifiers and miscellaneous information. The work of the committee is attracting so much attention that requests for information regarding its data have been received from some of the largest cities of the Continent, notably from Paris and Brussels.

The Concrete Dam of the Lynchburg Water Supply.

The concrete block dam for the 500,000,000-gal. reservoir on the Peddlar River supply of Lynchburg, Va., was completed and put in service early in 1907. The design and method of construction were illustrated in The Engineering Record of May 12, 1906, but after the completion of the dam considerable supplementary work was executed for the distribution of the water. The dam delivers water at a head of about 20 ft. above that of the old service and eliminates a pumping plant formerly required. It has a total height of about 70 ft. above the rock, with a maximum depth of the water on the up-stream face of about 60 ft. Owing to the care with which the blocks were laid the seepage through the concrete is negligible, all of it being evaporated so as to be imperceptible in warm weather, so that no flow ever exists on the downstream surface.



Two Views of the Completed Concrete Dam of the Lynchburg, Virginia, Water Supply.

The concrete is of a remarkably uniform appearance and the color is regular and pleasing, although no special treatment was given it after the forms were removed. In the accompanying view the water is shown running over the crest of the dam at a depth of about 6 in., but in the recent spring freshets it was submerged to a depth of 2 ft. It will be remembered that the hollow space under the apron was vented with perforated horizontal pipes provided to prevent the possibility of the formation of a vacuum which would reduce the stability of the structure. The efficiency of this provision is demonstrated not only by the manner in which the dam has resisted adverse conditions, but by the very strong inward current of air through the ends of the 6-in. vent pipes during a heavy flow over the crest.

The 30-ft. weir built across the channel of the river 200 ft. below the main dam has very satisfactorily served its purpose of producing a water cushion which has entirely prevented any erosion at the toe of the dam. Besides this it has been very useful as a measuring weir, and the observations daily recorded have supplemented those taken in times of flood on the main dam so as to provide a record that has not previously existed of the actual yield of watersheds of this character in this district.

Water is delivered from the reservoir to the city of Lynchburg, about 30 miles distant, through a 30-in. stave pipe, with a calculated capacity of 8,000,000 gal. per day. The vertical alignment of this pipe is very irregular, approximately following in many cases the contours of the mountain region and giving it in some places a pressure head of 400 ft., where, of course, the construction is changed to lock-bar steel or cast-iron, the wood pipe being limited to heads of 200 ft. or less, and cast-iron being adopted for all stream crossings.

The lower end of the pipe terminates in a steel stand pipe, 60 ft. high, which provides pressure for the high-service distribution of the city. After this service has been supplied the remaining water overflows into the circular distributing reservoir, in the center of which the standpipe is located. As it is essential that the wooden pipe be completely filled at all times with water under pressure to insure its preservation, special provision was necessary to regulate its discharge to an amount approximately equal to 150 per cent of the daily consumption, which now averages 300,000,000 gal.

This was effected by a series of standpipes, about five miles apart, with gate valves in the main conduit just below each of these standpipes. The manipulation of these valves, together with those at the reservoir outlet in the city, enables the flow to be throttled so that a small stream of water constantly flows out of the top of each standpipe on the line, thus limiting and insuring the delivery of 4,500,000 gal. of water daily to the city. This, of course, demonstrates that the pipes are completely filled and that there are no air-bound sections, automatic air valves being provided at all summits to remove the air that is liberated from the water by changes of temperature and pressure. The rise in temperature to which the water is subjected in flowing from the bottom of the reservoir through protected pipes liberates enough air so that considerable flow is often noticed through the valves. Great care was taken by the designing engineer to adjust the valves with accuracy when the pipe was put in service. Since then they have required little or no change, and the constant uniform overflow from the standpipes indicates the regularity with which the system operates.

This system was put in service before its entire completion, and the problem involved by supplying the city directly from the conduit, while the distributing reservoir was out of service, for the construction of the standpipe in it, was a delicate and serious one. The temporary connection to the distribution system was made under a pressure head of approximately 75 ft., which gave a pressure sufficient for a flow of 4,500,000 gal. daily through a very small opening in the 30-in. valves. The valve itself was therefore closed tightly, and the entire supply was taken through a 6-in. by-pass. In order to provide against the destructive effects of water hammer in the 30-mile conduit, a man was stationed day and night at this point in a temporary wooden building, where a pressure gauge was installed on each side of the by-pass, and a blow-off valve was placed to enable him to relieve the pressure as soon as a serious increase was observed. The necessity for this provision was evident from the fact that changes of pressure of 50 lb. sometimes occurred within a few seconds without obvious reason and was supposed to probably be due to the surging of the long columns of water.

An additional security was afforded by an automatic relief valve set to open with a variation of 1 lb. pressure. This was located on the connection to the old standpipe and discharged to the sewer. This pipe, having a diameter of only 4 in., would not suffice alone, but with the additional security afforded by the watchman the domestic, public and fire service was maintained for a month without the necessity of using the old supply pumps and without any damage being sustained by the new system. Steam, however, was maintained in the old pumping plant to provide for any emergency in case the flow which had been arbitrarily limited should prove insufficient, but such operation was not required. The system is now entirely completed and has been satisfactory and continued operation for several months. It was designed and the construction was supervised by Mr. James H. Fuertes, consulting engineer, and H. L. Shaner, city engineer, in charge of the construction. Mr. Chauncey G. Williams was the contractor for both pipe line and reservoir.

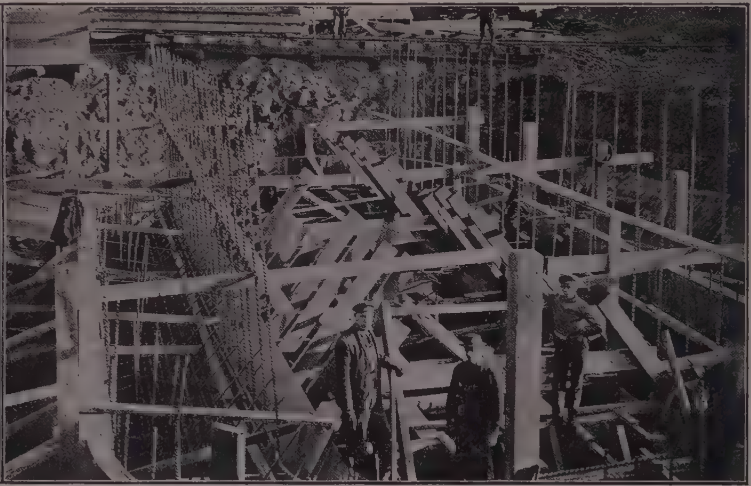
A Reinforced Concrete Reservoir with a capacity of 2,100,000 imp. gal. has been built at Shedfield, Eng., for the Gosport Waterworks Co. It is 200 ft. long, 126 ft. wide, 16 ft. deep and holds 14 ft. of water. It is divided into two equal parts by a wall 8 ft. 6 in. high. The covered top is about 7 ft. above the average original level of the site, and with the 2-ft. earth covering requires an embankment 9 ft. above normal ground level. The foundation is a 7-in. continuous slab, reinforced to withstand tensile stresses in either the top or bottom surface. The walls are vertical panels 6 in. thick at the bottom, 4 in. at the top, stiffened by exterior counterforts on 5-ft. centers. The roof is of reinforced concrete beam and girder construction, carried on concrete columns. The reinforcement is of the Monchel-Hennebique type. The reservoir was described in "The Surveyor," from which these notes were taken.

Sinking a Concrete-Lined Mine Shaft.

A mine shaft, consisting of an open concrete caisson, is being sunk through 79 ft. water-bearing soil overlying bedrock at the Woodward colliery of the Delaware, Lackawanna & Western Railroad Co., about a mile from Wilkes-Barre, Pa. This shaft has straight sides and curved ends, the concrete enclosure being 48 ft. 10 in. long by 14 ft. wide. Eventually this enclosure will be divided, making in effect three separate shafts, one to accommodate two cages for hoisting coal, one for a pump and ladder way and one for an upcast airway.

While this method of shaft construction is an unusual engineering undertaking in this region, perhaps the chief feature of interest connected with it is the manner in which it evidences the vast change in anthracite coal mining methods brought about by the exhaustion of the veins, which were comparatively easy to reach. The first anthracite coal was taken from the outcroppings, where the coal strata came to the surface of the earth. When this method was no longer possible the most accessible and thickest veins were next mined. At that time the aim was to get the greatest possible amount of coal for the least possible outlay, and little thought was given to advanced methods to prevent waste and conserve the future supply, which ideas are now all changed. The thick veins of coal lying near the surface have practically been exhausted in most of the anthracite region. Shafts were sunk to the thicker veins, and where there are thinner underlying veins the shafts have to be sunk deeper to supply the demands for coal.

Erecting Concrete Forms on the Steel Shoe.


Placing Reinforcing Metal for Concrete Walls.

In order to mine the coal it is necessary to have the openings over the roadways about 6 ft. in height to accommodate the mules and cars, and as the thin veins vary from 2½ to 5 ft. in thickness, enough rock must be removed to obtain this height. The exhaustion of the thicker veins has also caused a breaking of the overlying strata, which causes a large inflow of water. The consequent pumping, the increasing length of haulage ways in the mines, hoisting and ventilation are far more serious problems than were encountered a generation ago. The cost of mining as a result is increasing with the difficulties.

It follows from the fact that the anthracite in the most available locations has been well-nigh exhausted, that shafts must be sunk in more unfavorable and hazardous locations, in places where operations would never have been located in the earlier stages of mining. This condition holds in the case of the new shaft of the Woodward colliery. This shaft is on the flat lands of the Susquehanna River, which flats are only a few feet above the normal level of the river and are water-overflowed nearly every year.

The character of the soil at the site, combined with the proximity of the river, led the company's engineers to decide on a concrete shaft wall or open caisson method of construction. Layers of sand, gravel, quicksand and clay overlie the bedrock. An excavation into these materials at any point encounters water at about the same level as exists in the river. In sinking a shaft through the existing materials under this condition, it is considered to be even more difficult than it would be to put a shaft in the river itself. The use of any other method than the one employed was also considered to be much more hazardous to the maintenance of the shaft and the preservation of life.

The contract for sinking the concrete shaft and connecting it with the rock strata was let to the Foundation Company of New York. In sinking the shaft this company first constructed a steel shoe, generally oblong in shape and with rounded corners. The length of this shoe over all was 59.5 ft. and its width 28 ft. The outer extremity of the shoe consists of ½-in. steel cutting edge and is about 30 in. in height. To this cutting edge is riveted on the inner side, and about 8 in. from the bottom, a horizontal steel plate, ½ in. thick and 24 in. wide, which serves as a shelf to support the concrete. The latter tapers inwardly to a thickness of 7 ft. on the sides.

A pit was dug to a depth of about 15 ft. when operations were started. This steel cutting edge was placed on the bottom of this pit and made perfectly level, the edge surrounding the location chosen for the shaft. Forms were then made of wood for the concrete walls, and laid on the steel shoe to a height of about 20 ft. When the concrete had been placed in these forms and had become sufficiently hardened an excavation was started in the enclosed space, and the spoil hoisted by means of a bucket. As the excavation progressed the weight of the concrete walls on the steel cutting edge gradually forced the latter downward. As sinking progressed more concrete was laid on the top of that already placed. In this manner the concrete walls made their own way through the materials overlying the rock. As fast as the concrete had set under the lower section the forms were removed and another section of the concrete added to the top by the use of the same forms, thus continually adding to the weight.

Care and skill were required to keep the concrete walls vertical, or, in other words, to keep one part from sinking faster than another. This required constant watchfulness, and where one part was found to be sinking more rapidly than another the adjacent excavation from the inside was increased or decreased accordingly. This process was continued until the walls reached solid rock, a depth of 79 ft.

At the top the concrete walls extend from 15 to 20 ft. above the ground, so that when the surrounding surface is under water the shaft may be kept perfectly dry, the height of the walls being more than enough to protect the shaft from the highest water mark ever reached in the vicinity. When the cutting edge reached rock the top of the rock was found to be somewhat uneven, and the space between the rock and cutting edge was securely caulked, by means of wooden wedges, to keep the interior of the shaft as dry as possible.

The concrete shaft walls above rock being in place, the rock was blasted out beneath the concrete walls to within about 2 ft. of the outer edge of the latter and to a depth of about 20 ft. Forms will be erected to a depth of about 20 ft. below the top of the rock up to the base of the concrete walls. These forms will also be poured with concrete, making the inner surface perfectly plumb and water-tight to this depth.

Then the quarrying of the rock for the shaft proper will be continued by local contractors. Up to the point of uniting the rock with the concrete walls about $70,000 has been expended. Before the Foundation Company will have completed their job the cost will have reached about $75,000. The walls will contain 3,000 cu. yds. of concrete and 145 tons of reinforcing steel. The rock and sand used in this concrete work was obtained in the vicinity of Scranton, Pa., and the cement from New Jersey.

Top of the Completed Colliery Shaft.

When the concrete portion of the shaft is completed a total depth of about 100 ft. will have been reached. The total depth of the shaft will be about 805 ft., at an estimated cost of $200,000, after which, at an additional expense, it will be necessary to install two large ventilating fans, one to be used in case of emergency. Each of these will have a capacity of about 350,000 cu. ft of air per minute; hoisting engines and pumping plants will also have to be installed before any coal will be mined.

The process of sinking has been in progress about six months and it will require at least another year before mining operations can be started.

Eels in Water Mains have caused trouble in a good many cities, but Brooklyn, N. Y., is now afflicted with unusual numbers of them. In one day alone 68 complaints about them were made to the deputy water commissioner, and at one schoolhouse about 200 of them, from 6 to 17½ in. long, have been taken. During a warehouse fire, the water supply to the private fire-hose connections was shut off by a large eel caught in the water meter. The eels doubtless enter the mains from the reservoirs when they are very small and can slip through the meshes of the screens in the gate houses. They grow in the mains and finally find their way into the smaller street pipes, so that when a strong draught is made on one of these pipes for any reason they are carried along by the current. Attempts are being made to flush them out by opening the hydrants at night, when the water pressure is greatest.

Experiments with Railway Cross-Ties.

Some time ago the U. S. Forest Service entered into an agreement with the Northern Pacific Railroad to investigate the tie timber accessible to its line, in order to determine the best and most economical methods of handling these timbers when manufactured into cross-ties. The timbers used in the experiment were Douglas fir, western hemlock, western tamarack (western larch) and giant arborvitæ. The investigation consisted of three separate experiments: First, tests to determine the green weight and rate of seasoning of timbers cut in different months; second, tests to determine the absorptive power of seasoned timbers cut in different months; third, tests to determine the comparative durability of green, seasoned and treated timbers when laid under similar conditions and with various tie-plates and rail fastenings, in a test track.

Two stations were established for conducting the seasoning tests—at Tacoma, Wash., and Sandpoint, Idaho. A substation to the Tacoma experiment was placed at Pasco, Wash. Half of the ties cut each month at Tacoma were shipped to Pasco to compare the rate of seasoning in the two places, which differ widely in climate. The average of these stations gives the average rate of seasoning of Douglas fir for all conditions to be encountered in the Northwest.

Two separate test tracks were constructed, one on the west slope of the Cascade Mountains, near Maywood, Wash., and one in western Montana, near Plains. The final conclusions will be obtained from the test tracks, but cannot be given yet. The seasoning experiments are described in a Forest Service bulletin by Mr. H. B. Eastman, from which the following notes have been taken.

Douglas fir was used exclusively in the seasoning experiments at Tacoma and Pasco. The ties were sawed from logs ranging from 3 to 6 ft. in diameter. The wood showed from 4 to 36 rings per radial inch. The sapwood of Douglas fir seldom exceeds 3 in. Owing to this fact and the custom of sawing ties from coarse heartwood timber, the seasoning experiments on Douglas fir show a small loss of moisture in per cent of green weight, as compared with other species.

Four hundred ties were cut each month of the year from November, 1903, to December, 1904, except that in September, 1904, none were cut. Of these, 200 ties were marked, weighed and shipped each month to Pasco. A new series was started at Tacoma in December, 1904, and continued until July, 1905, to act as a check on the first series through the rainy season. As a rule, the ties were weighed within three and one-half days from the time the trees were felled; hence the first weight is the approximate green weight.

A 7 by 2 pile was adopted at both Tacoma and Pasco, with 50 ties in each pile. Two piles of each series of 200 ties were faced north and south and two piles east and west.

A monthly meteorological table prepared by the United States Weather Bureau station at Tacoma was used to show whether the ties seasoned under normal conditions and to determine what effect climatic changes had upon the amount and rate of seasoning. No such data were obtainable at Pasco.

The green weight of Douglas fir, based on the data obtained from 4,000 ties seasoned at Tacoma, shows a seasonal variation from 37 lb. per cubic foot in July to 41.7 lb. in February and March. A thousand feet, board measure, of the July timbers weighed 3,082 lb., of the February and March timbers 3,474 lb. The yearly average was 3,284 lb. per thousand feet. These results correspond very closely to the rough green weight of 3,300 lb. adopted by the lumber associations in the Northwest.

Table 1 shows the green and seasoned weight per cubic foot of Douglas fir. The seasoned weight is based on eleven months' seasoning. The column on the right gives the time required for the various months' cuts to reach their minimum weight.

Table 1.—Green and Seasoned Weight of Douglas Fir.

Month cut.	Weight per cubic foot. Green. Pounds.	Weight per cubic foot. Dry. Pounds.	Seasoning period to reach minimum weight. Months.
January	39.7	33.4	7
February	41.7	34.9	6
March	41.7	35.4	5
April	39.4	34.0	4
May	39.0	35.1	4
June	38.3	34.3	3
July	37.0	33.1	10
August	39.4	34.9	11
September	39.0	34.0	11
October	38.5	33.1	10
November	40.2	34.4	9
December	39.6	33.4	8
Average	39.5	34.2	7.3

The oven-dry weight is 28.3 lb. per cu. ft.

The seasoning experiments at Tacoma and Pasco showed that there is little difference in the rate of seasoning of timbers stacked in piles which face different directions. The greatest difference for any single month was 2 per cent, while the average difference for a year's cut, based on eleven months' seasoning, was 0.05 per cent at Tacoma and 0.02 at Pasco.

The oven-dry weight of Douglas fir used as a basis in the experiment to determine the rate of seasoning was taken from data established by Professor Hunt at Berkeley, Cal. His results show a variation from 22.1 to 36.2 lb. per cubic foot. The average for all grades, 28.3 lb. per cubic foot, was taken as the basis.

The results of the test furnish a comparison of the maximum and minimum rates of seasoning of Douglas fir under two entirely different climatic conditions. While the weight per cubic foot and moisture content of the green timber seasoned at each station was practically the same, there is a wide difference in the rate of seasoning. On account of the uniform rate of seasoning of certain months' cuts at Pasco, it has been possible to make four groups and thereby simplify the results. The following four groups were therefore made: (1) October, November, December and January; (2) February, March, April and May; (3) June and July; (4) August and September. It is impossible to group the monthly cuts at Tacoma.

Three important conclusions are drawn by Mr. Eastman from seasoning timbers under different climatic conditions: (1) Timbers cut during different months will eventually reach approximately the same weight per cubic foot in regions with a minimum rainfall; but in humid climates the maximum loss in weight corresponds closely to the seasonal variation in the green weight. These results failed to substantiate the theory that the varying physical characteristics of timber cut at different seasons determine the minimum air-seasoned weight. (2) Rainfall is the chief factor in determining the rate of seasoning. (3) The rate of seasoning determines, to a great extent, the resultant behavior of the timber as to checking.

In order to determine the effect of the rate of seasoning upon the condition of the timber, frequent photographs were taken of each month's cut. Two kinds of checks were observed—radial and small honeycomb. Honeycomb checks occur on timbers which season slowly during the first few months. Radial checks occur on timbers which season rapidly during the first few months, that is, timbers which are cut during the period from June to September. A study of these two forms of checks indicates that honeycomb checks cause little damage to the tie, while radial checks are very destructive and often make the tie unfit for service. Because of the excessive checking of Douglas fir, many eastern concerns will not use this timber in large dimensions. In view of these seasoning experiments, it is believed that this objection can be eliminated and the market of Douglas fir extended. Cutting should be limited to the months from November to April, inclusive, and the timber seasoned for at least ninety days before being shipped through the arid region east of the Cascade Mountains.

Four hundred and fifty of the ties seasoned at Tacoma were selected for treatment by the straight creosote method. After treatment the ties were again seasoned four months before being placed in the track. In order to determine the absorption by increase in weight the ties were weighed before and after treatment, then ninety days later. The increase in weight during treatment was 8.6 lb. per cubic foot. After ninety days' seasoning an average of 2.4 lb. of this increase had been lost, leaving the net increase per cubic foot 6.2 lb. When the ties were placed in the track they contained an average of about 6 lb. of creosote per cubic foot.

The timbers used in the Idaho experiment were Douglas fir, western tamarack and giant arborvitæ. The Douglas fir of Idaho and Montana differs greatly from that of the Pacific slope, as it seldom reaches 3 ft. in diameter. From stem analysis it was found that the age of the Douglas fir from which the ties were cut varied from 96 to 151 years, and of the tamarack ties from 100 to 205 years. The ties were generally hewed and varied much in size and shape. In consequence of this it was impossible to determine their volume accurately; therefore the seasoning results are expressed in per cent of the first or green weight of the ties. Meteorological data were not available, but with the exception of October, 1905, when heavy rains occurred just before the weighings, the seasoning took place under normal conditions.

From September, 1904, to April, 1905, a total of 2,350 ties were cut; divided nearly equally between the fir and tamarack. As a rule, 200 ties of each species were cut each month; of this number, 50 ties were peeled and piled to correspond in form and position with a pile of unpeeled ties.

Three forms of piles were used—7 by 2, 8 by 1, and solid. As a rule, the 7 by 2 piles showed a greater loss than the 8 by 1 piles, though the average difference was very small. The solid piles seasoned much slower than the open piles during the first few months, but their minimum weight gradually approached that of the open piles and were about equal after twelve months' seasoning.

The peeling of timbers was found to be the most important factor in determining the rate of seasoning. Since the unpeeled ties, piled in different forms, seasoned at approximately the same rate, the results of each form have been averaged. They indicate that peeled Douglas fir ties, cut during November, December and January, will have seasoned sufficiently for treatment by the following May, whereas unpeeled ties of the same months' cuts do not reach as low a moisture content until from three to five months later. The same general conclusions are applicable to western tamarack, except that its rate of seasoning is much slower and, because of its thin bark, the difference between the peeled and unpeeled ties is less marked.

In view of these results the peeling of all ties as soon as cut is highly recommended. Not only is there greater rapidity of seasoning, but the peeled ties are more uniform in shape and so permit a greater number to be shipped per carload. It would not seem profitable to air-season the ties completely if they are to be treated, but if the timbers are to be used untreated the greatest durability will be secured by continuing the seasoning until the most complete air-seasoned condition has been reached.

The peeling of ties as soon as cut allows more seasoning during the first few months, when ties are usually shipped, and therefore means a saving in freight. To determine this a number of ties were weighed before and after they were peeled and compared with unpeeled ties. At the end of six months the peeled ties lost 34 lb. more than the unpeeled; of this loss, 15 lb. was the weight of the bark. The average volume of these ties was about 4 cu. ft. The average loss of weight of the peeled ties was 9.5 lb. per cubic foot, as compared with a loss of 4.75 lb. per cubic foot of the unpeeled ties.

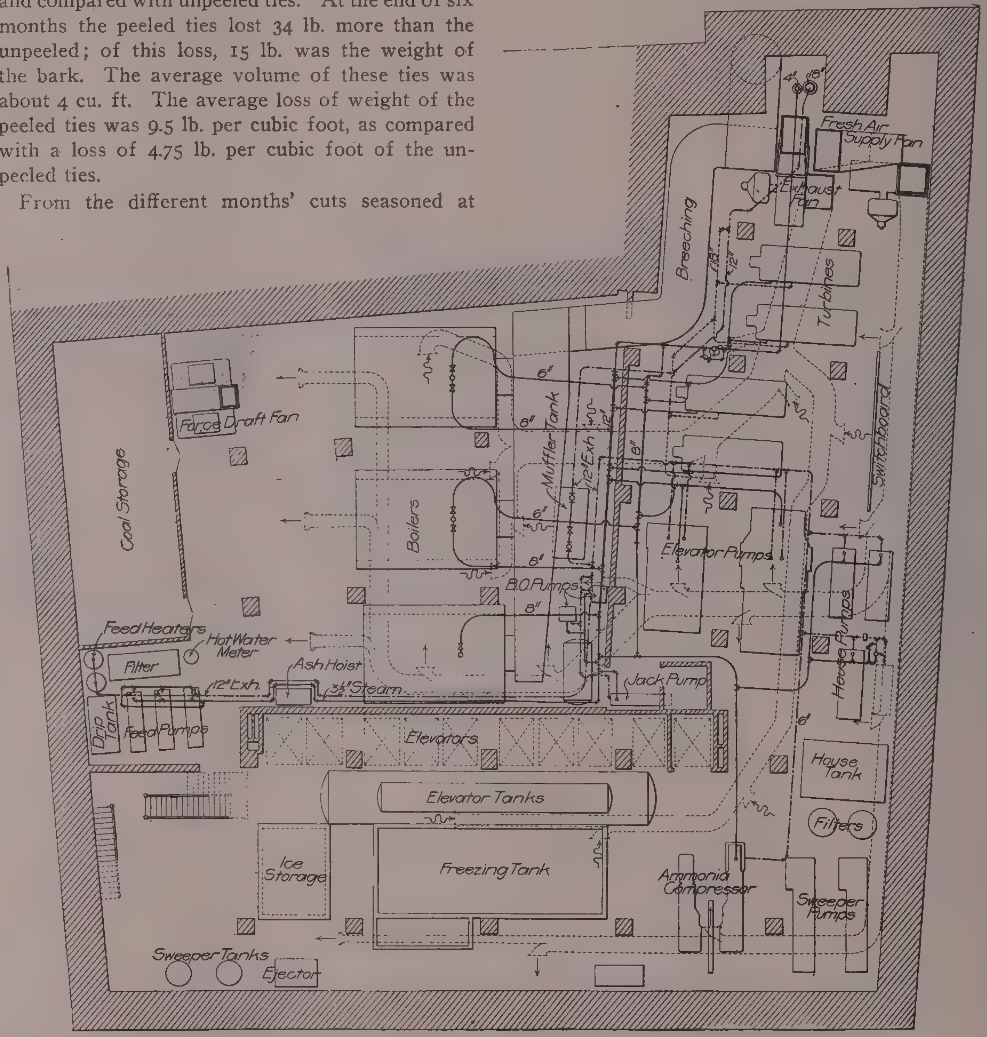
From the different months' cuts seasoned at Sandpoint several hundred ties were treated with zinc chloride, a 6 per cent solution being used. An estimate by the gauge readings showed an injection of 0.786 lb. of pure chloride per cubic foot of timber.

Both species were treated in the same charge, yet, as a rule, the tamarack ties show a better impregnation than the Douglas fir. The Douglas fir ties peeled directly before treatment were more susceptible to preservatives than those peeled when cut. These results are contrary to general expectations, since the ties peeled when cut had reached a slightly lower moisture content than those peeled directly before treatment.

The Transportation of Coal from the ocean wharves of Genoa, Italy, to factories nearby has been greatly facilitated by the construction of a tunnel 902 ft. long cut through the solid rock. It saves a long ascending grade, and according to a consular report will be operated with 3-ton cars hauled by mules.

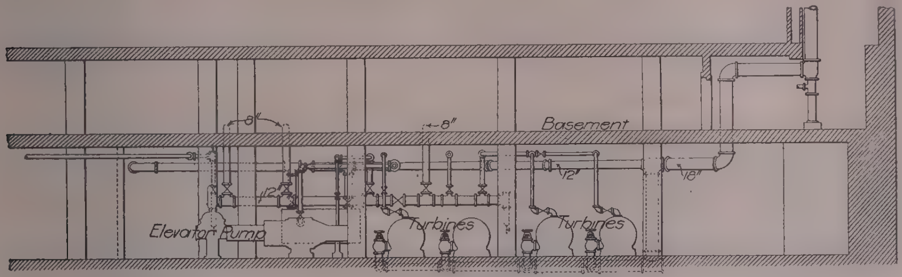
Mechanical Plant of the United States Express Company's Building, New York City.

A 22-story steel frame office building with a basement and sub-basement has recently been completed by the United States Express Company for the accommodation of its extensive New York City offices and for office rental purposes on the upper floors. The structure occupies an irregularly-shaped plot, approximately 130 x 140 ft. in size, facing Rector St. and extending from Trinity Place to Greenwich St., and has a total height of 305 ft. above the curb, or 325 ft. above the cellar floor level. The construction is thoroughly fireproof, consisting of terra-cotta outside finish, hollow-tile floors and partitions and metal-covered windows and door frames throughout, very little wood being used in any part of the building. The lower floors are utilized for the general business offices and public offices of the express company, with a freight handling department and enclosed dray loading platforms within the building on the Greenwich St. side, while in the upper portion of the building there are seventeen floors devoted to rentable offices, each having a total floor area of over 14,000 sq. ft. Details of the interesting constructional features of this building were referred to in articles in The Engineering Record for March 3 and July 28, 1906.



Mechanical Plant in Sub-Basement, United States Express Building.

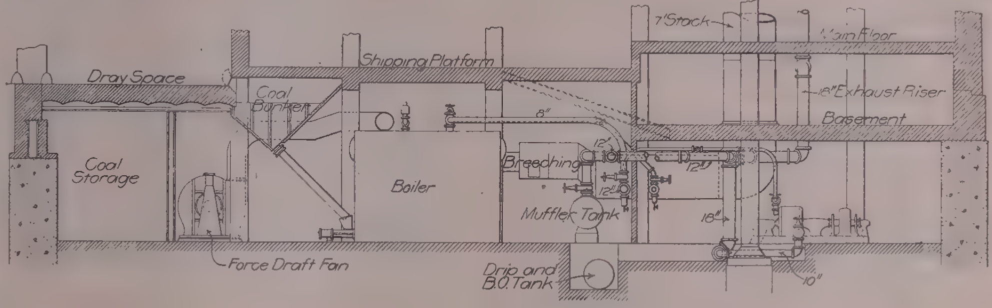
In the operation of the building the usual mechanical services are involved, including heating, lighting, power for elevators and auxiliary machinery and ventilation, and, in addition, a feature of novelty has been introduced in the form of a refrigerating plant, solely for ice-making and cooling purposes within the building. For the operation of this equipment a 1,050 h.-p. boiler plant has been installed, while the lighting plant consists of four turbo-generators, aggregating 600-k.w. rated capacity, the elevator plant of ten high-rise plunger elevator machines operated by two high-duty duplex pumps and the refrigerating plant of a 40-ton ammonia compression machine, with 20-ton ice-making equipment. The entire cellar space was required to accommodate this equipment, consisting of an irregular-shaped space, 108 ft. in width at the Rector St. front, 120 ft. in width at the rear by 132 ft. in total depth. The cellar space does not, however, extend under the entire site, a section 30 x 90 ft. in extent, at the rear side of the building on the Greenwich St. side, not having been excavated. The available space is divided into a boiler room, engine room and refrigerator machinery room, the boiler room adjoining the unexcavated space occupying approximately 55 x 75 ft.; the engine room on the opposite side adjoining Trinity Place, 40 x 90 ft. in dimensions, and refrigerating machinery room on the Rector St. front, 40 x 110 ft. in size. Over the rear of the refrigerating machinery space are located the elevator shafts, and at this point there are, in a space of 16 x 65 ft., the elevator machine valves and the elevator pressure and discharge tanks. Lack of space in the boiler room prohibited a convenient arrangement of feed pumps and heater in close proximity to the machinery sections, but an arrangement was finally chosen in which this equipment was conveniently located in a small room in the westerly side of the basement near the firing floor.



Section through the Turbine Room.

The combined mechanical services of the building for which the power plant was installed embrace a total of 37,000 sq. ft. of direct radiation for heating purposes; a lighting load averaging from 1,500 to 1,800 amperes, there being about 7,000 16 candle-power incandescent lamps connected; an elevator load of five express and five local high-rise plunger elevators, with ash lift and money hoist for the express company's offices, all hydraulically operated; a motor load of nearly 200 h.-p. connected for the operation of vacuum pumps for the sweeper apparatus, for ventilating fans, ice-water circulation and other auxiliary machinery and the 40-ton refrigerating compressor. For this service it was decided to install three boilers of 350 h.-p. capacity each, any two of which can, it is calculated, carry the maximum plant load with a considerable margin of reserve capacity, thus leaving one boiler unit always in reserve. The electrical generating equipment is similarly proportioned for a capacity considerably in excess of the maximum lighting and power requirements, and by the provision of four units of equal capacity, the capacity of apparatus in operation can be most easily adjusted to the load requirements

A feature of this mechanical plant is an unusual fuel storage for a building of this character. There is in the front side of the boiler room a large enclosure for storage of coal, while over the firing floor there are in addition suspended steel bunkers with down spouts for delivery of coal direct to the stoker hoppers. The storage enclosure is a room 15 x 43 ft. in inside measurement, with 18 ft. clear head-room, which is separated from the boiler room by a well-braced steel partition and has a capacity, when filled, for approximately 500 tons of coal. The suspended bunkers are steel hoppers with inclined bottoms, which are 14 ft. in width and varying length over each boiler front, and are suspended from the first floor steel work. Through a fortunate arrangement of the ground floor plan, involving a shipping platform and enclosed space for drays and wagons within the building at the rear on the Greenwich St. side, it is possible to deliver coal from wagons directly to either the bunkers or the large storage rooms, openings into the former being located in the front of the shipping platform and to the latter in the form of coal holes at frequent intervals in the dray space floor. These facilities combined provide for a storage of nearly 600 tons of fuel, that in the bunkers being delivered by gravity to the stoker hoppers, while the coal in the storage room is brought to the boilers in barrows. The ashes, which are removed in the usual way in cans for dumping into wagons, are elevated to the surface by a plunger ash hoist that rises from one end of the firing floor to the shipping platform level for ease of handling. The express company handles its own coal and ashes, having two 7-ton trucks for the purpose, coal being hauled from Jersey City to the building and ashes carried back on the return trip, to dumping grounds there which the company owns.



Cross Section through Boiler and Turbine Rooms.

Three sectional water-tube boilers of the internally-fired type, built by the Munoz Boiler Co., Dayton, Ohio, are installed. They consist each of two horizontal steam and water drums arranged longitudinally at either side of the top of the settings, with cross-connecting headers at both front and rear into which the front and rear tube headers of an inclined bank of water tubes connect; outside of the inclined bank of tubes there are vertical tubes connecting the base of either steam drum, with a small mud drum arranged longitudinally directly underneath. The steam drums are 36 in. in diameter by 20 ft. in length, and each connect with the mud drum underneath it by twenty 4-in. vertical tubes; the inclined bank of tubes consist of one hundred and twenty-six 4-in. tubes, 18 ft. in length, which are arranged in 14 rows, each 9 tubes high and connecting into vertical cast-steel tube headers of serpentine form. The boilers have each a rating of 350 h.-p. and are designed for 185-lb. pressure, although a working pressure of 160 lb. is carried. A feature of the Munoz boiler construction is the replacement of the usual brick setting walls by metal casings, which permit of easy access to all parts of the heating surface. The vertical side tubes which connect either drum with the lower rear tube headers and enclose the furnace and combustion chambers on either side, are intended to both facilitate the circulation of water in the boiler and to absorb the heat that would otherwise pass from the gases into the setting walls. The boilers deliver steam through 8-in. nozzles, which have connections to the two drums through inside separators for the delivery of dry steam.

The furnaces are fitted with Jones' under-feed stokers, and provisions are made for the delivery of coal direct from the elevated bunkers into the stoker hoppers. Manual handling of the fuel is thus eliminated, except as coal from the reserve storage room at the rear of the firing floor is used, when it will be necessary, as already stated, to wheel the coal in barrows and shovel it to the stoker hoppers. Automatic regulation of steam pressure is provided for by a Jones system of forced draft operated in connection with the stoker drives, the intensity of the draft and the rate of feeding the fuel being varied by the steam pressure, and thus in accordance with the power requirements of the plant. The forced draft is furnished by a centrifugal blower located in the rear corner of the firing floor. This blower is fitted with duplicate steam engine drives, either of which may be easily connected to it, to insure continuity of service. The products of combustion are removed from the boiler settings by a rectangular sheet-iron breeching at the rear of the setting. This breeching varies from 5 x 4 ft. to 5 x 8 ft. in section and connects thence to the base of the stack through a duct connection 6 x 7 ft. in cross section, extending through the rear end of the engine room. This entire breeching is covered with block magnesia, over 2-in. air space, and the whole is enclosed in a light galvanized-iron casing. A 7-ft. steel stack near the north wall of the building on the easterly side rises above the roof level to a height of approximately 325 ft. above the boiler room floor. The breeching is fitted with an Ashcroft pyrometer for temperature measurements of the flue gases and has a main damper turning on roller bearings that is operated by a Kieley damper regulator.

The boilers are fed by an equipment of three duplex feed pumps, which are connected to draw either from open feed-water heaters or from the city water mains, and all of the feed is passed through a Ward water filter. The feed pumps are all 7½ x 4½ x 10-in. Worthington brass fitted duplex pumps of the outside end packed type with pot valves. These pumps are supplied with steam by a 3½-in. branch from the main steam header and exhaust into the extension of the exhaust steam main which supplies the open feed-water heater. There are two Kieley open feed-water heaters, each of 800 h.-p. capacity, into which all water of condensation returned from the heating system or other apparatus is delivered, with make-up water supplied as needed from the city water system by a hand valve. The feed-water filter is of the Ward combination zinc box and charcoal pattern, consisting of ten vertical cast-iron cylinders, of the usual construction, with animal charcoal filling and outside strainer box.

Delivery to the boilers is provided for by two 3-in. feed mains in duplicate, each with 2-in. delivery connections to each boiler unit, which are substantially erected with flanged joints and are cross connected to the pumps, feed-water heaters and injectors. The feed piping is provided with thermometer sockets for temperature measurements in testing, and there is also installed a 4-in. Worthington hot-water meter through which the feed delivery may be passed, if desired. Two Metropolitan Model O double-tube injectors are installed to supplement the feed pumps and for boiler-testing purposes. These injectors have suction connections to the water service mains from the street and deliver through either of the regular feed mains.

The boilers have blow-off connections from the lower rear ends of the water connections, or mud drums which deliver through a short direct 4-in. main to a cylindrical blow-off tank in a pump pit at the rear of the settings. This tank is a 9 ft. cylindrical tank 4 ft. in diameter, built of ⅜-in. boiler plate, which is vented to the air through a vapor pipe leading to an exhaust head above the roof and is arranged to be drained by either one of two 6 x 4 x 6-in. Worthington duplex pumps that serve this blow-off tank and the sump drainage. These pumps are of brass-fitted construction similar to those for boiler feeding, and are controlled automatically to drain the blow-off tank by means of a Kieley pump governor, while the sump pit drainage is removed under float-valve control. The usual coil is provided for cooling the blow-off discharge, consisting of a coil of 100 lineal feet of 2-in. brass pipe placed in the blow-off tank, through which the cold-water supply to the feed pumps is drawn from the city water mains; and in addition to this coil there is also provided a radiating coil through which the blow-off discharge is finally circulated before delivery to the sewer. This radiating coil contains 1,000 lineal feet of 1¼-in. iron pipe and is partially enclosed in a galvanized-iron casing to prevent the radiation into the machinery room.

The high-pressure steam piping has been laid out with two headers, one a main line from which the steam turbines and the elevator pumps are supplied, and the other an auxiliary line, both headers having separate supply connections from the boilers and cross connections between them for interchangeability in service. These headers are arranged longitudinally on either side of the boiler and engine room division wall, both at levels about 8 ft. above the floor. The main header is a 12-in. line on the boiler-room side and the auxiliary an 8-in. line in the turbine room. They have 8 and 6-in. supply connections, respectively, from the boiler nozzles, which connections are fitted in each case with non-return stop and check valves at the boiler nozzles and gate valves at the header. Both headers are separated by sectionalizing valves into two divisions so that by means of the cross connections either header may be used for the delivery of steam to any of the steam-using apparatus, in case of necessary changes or repairs. Drainage of condensation from the high-pressure piping is provided for from the headers, which are in both cases located much lower than either the boiler or delivery branches. These connections are in all cases made from the top sides of the headers. Both headers have drip pockets at either end, from which the condensation is drained through Bundy traps to the muffler tank or to a drip tank for return to the boilers. The high-pressure piping is erected throughout with long radius bends at all angles and tees to provide for expansion, all lines of 6-in. piping and larger being fitted with Van Stone joints, and connections down to 3 in. in size with screwed-flange joints. The pipe insulation is 85 per cent. magnesia, over which there is a protecting covering consisting of rosin-sized paper and 8-oz. canvas, brass banded. Condensation from the high-pressure system is received in a cylindrical drip tank, 4 ft. in diameter and 8 ft. long, into which is delivered all condensation from the mains through Anderson traps, and also the condensation returns from the heating system. A 3-in. vapor connection is extended from this tank to the vapor line rising to the roof for relief of pressure.

The exhaust steam piping is, owing to the use of the exhaust for heating, laid out in two divisions; one for that from the reciprocating engines and pumps, where it is liable to be contaminated from lubricating oil, and the other for the exhaust from the steam turbines which does not require oil separation. The former division consists of a 12-in. header in the engine room, which receives the exhaust from the elevator pumps, the ammonia-compressor engine and the miscellaneous pumps, and extends thence to the boiler room, where connection is made to a muffler tank and oil separator at the rear of the boiler settings. From the muffler tank the exhaust steam is delivered either to the atmosphere, or to the heating system of the building through a 12-in. line extending to the rear end of the engine room and there connecting with a riser to the attic. The steam turbines exhaust through 10-in. connections to a 14-in. line that increases to 16 in. and finally to 18 in., and at the rear of the engine room joins with the 12-in. line from the muffler tank for delivery to the heating system. The riser to the attic is an 18-in. pipe that is carried up in a pipe shaft beside the smokestack as the main exhaust line, and connects in the attic space of the building to the heat distributing mains delivering through a back-pressure valve above this to the atmosphere in case of excess pressure. An 18-in. Kieley noiseless back-pressure relief valve is located in the riser near the roof line and connects directly above to a copper condenser head, which is designed to partially condense any exhaust wasted to the atmosphere, condensation being returned from the latter to the muffler tank through a 2-in. drainage connection.

A Kieley exhaust muffler tank and grease extractor, 54 in. in diameter by 10 ft. long, is located at the rear of the boiler settings and serves for the separation of oil. There are, in addition, two auxiliary connections to the exhaust steam system for water heating, one consisting of a 12-in. extension of the line through the boiler room to the feed-water heaters in the pump room on the Greenwich St. side, and the other a 5-in. connection from a portion of the exhaust system in the engine room to a hot water heater. The latter is on the ceiling on the Trinity Place side over the pumps for the plumbing service. Both of these connections thus act inductively and have Peerless grease extractors for the removal of oil, condensation being returned from the hot-water heater to the drip tank by an Anderson trap. The exhaust piping has an insulation covering similar to that of the high-pressure lines, and all lines 12 in. in size and larger are fitted with Van Stone joints, the smaller sizes having screwed flange fittings.

The electrical generating equipment consists of four 150-k.w. Curtis turbo generators, of the new horizontal type recently perfected by the General Electric Co. These units are of a special design for non-condensing operation to permit of the use of their exhaust for heating purposes in the building and also embody special features for the reduction of noise at the speed of operation of 2,000 r.p.m. Each unit is supplied with steam through a 3½-in. connection from the main steam header and exhausts through 10-in. connections into the independent exhaust mains that lead direct to the heating system without connection to the muffler tank. The turbine units are located in the northerly end of the cellar space in positions that would have been very inconvenient for reciprocating engine units, and are, moreover, very economical in space occupied, each unit requiring a floor space of only 5 by 15 ft. The exhaust pipe from each unit is provided with a steam whistle set to blow at a pressure over 10 lb., so as to prevent the turbines being started without opening the exhaust valves.

The electrical ends of the turbine sets consist in each case of four-pole, direct-current generators of the double-commutator type, wound for the delivery of 120 volts and having a special design of armature for this service and speed. These generators are compound wound, with equalizer connections to permit of operation in parallel, and have liberal ratings enabling considerable overload to be carried if necessary. The generator and distribution circuits of the building are controlled on a seven-panel marble switchboard on the opposite side of the room from the turbine unit, which comprises four generator panels, a totalizing and two feeder panels. The board has the usual equipment of instruments, circuit breakers and switches, there being on the total panel, in addition to the totalizing recording wattmeter, two smaller recording wattmeters, which may be used for the measurement of power delivered over any particular feeder line. Separate feeders are carried to all of the motors installed in various parts of the building. The normal day load supplied from this board ranges from 800 to 1,000 amperes, which is carried with ease by a single unit. This load rarely increases at night or other times of heavy requirement to such a degree that two of the turbo generators cannot handle it, leaving two of the units always in reserve.

The remaining mechanical equipment consists of two high-duty duplex pumps for the hydraulic elevator service, the refrigerating machines of the ammonia-compression type, a vacuum cleaning installation and three duplex pumps, which are used for house and fire service. The elevator pumps, installed to operate an equipment of 10 plunger hydraulic elevators, five operating local to the twelfth floor only and the remainder for express service to the upper floors, consist of two Davidson duplex pumps of the separable type, one with compound and the other with triple-expansion steam ends. The triple-expansion pump has 16, 24 and 38-in. steam cylinders, and the compound pump 17 and 32-in. steam cylinders, both units having 14½-in. water cylinders and a common stroke of 24 in. Both sides of either of the duplex units have independent steam and water connections and may be disconnected by the manipulation of valves and a simple releasing gear for subdividing the capacity of either unit by one-half. By reason of this separable feature the necessity of providing an additional unit for reserve purposes has been avoided, it being possible with this equipment to conduct repair work on either side of either pump without affecting in any way the operation of the other side of that unit.

The pressure and discharge tanks of the elevator system are located in the machinery room in front of the space occupied by the elevator operating valves. They consist of cylindrical steel tanks arranged horizontally, the discharge tank on the floor being 7½ ft. in diameter by 44 ft. long, and the pressure tank 4 x 32 ft. in size, suspended above. The elevators are operated on the back-pressure discharge system by means of which higher economy and better control of car operation are obtained. The connections are here made for discharge into the closed discharge tanks against a pressure developed by a stand-pipe overflow rising to a point of about 70 ft. above the cellar floor level.

The ammonia-compression refrigerating system, consisting of a complete equipment for a capacity of 40 tons, together with an ice-making equipment on the can system of 20 tons capacity, has been installed by the De La Vergne Machine Co., New York. A horizontal double-acting ammonia compressor, cross-driven by a Corliss engine at 60 r.p.m., is provided, the ammonia cylinder being 12 in. in diameter by 22-in. stroke, while the engine cylinder is 14 in. in diameter by 30-in. stroke. The ammonia is cooled in a condenser consisting of 840 lineal feet of pipe within pipe, through which water is circulated by either one or two Worthington centrifugal pumps of 100-gal. capacity per minute each. The principal feature of the refrigerating system is the supply of cooled water to drinking fountains placed in practically all rooms and offices in the upper portion of the building. The drinking-water supply, which is filtered through Loomis-Manning filters, is cooled by brine circulation in a special drinking-water tank in the cellar. From this tank it is circulated to and from balance tanks in the attic through sixteen risers to which the drinking fountains are connected, the circulation being made positive by a small centrifugal pump of capacity sufficient to circulate five times the consumption per hour. The capacity of the drinking-water system is for cooling 3,500 gal. of water per hour from a maximum of 80 deg. Fahr. down to 37 deg. The can ice equipment consists of a freezing tank holding eighty cans of 150-lb. cake capacity, a small traveling crane for handling these cans, a can thawing device and an ice storage room of 850 cu. ft. capacity.

Three house pumps of the 12 x 7 x 10-in. Worthington brass-fitted outside center-packed plunger type are placed adjacent to the elevator pumps, and are interconnected between the water service connections and plumbing tanks so that either unit may be used for any of the services. A 10 x 10 x 8-ft. open steel-plate tank is provided in the basement for storage for the plumbing system. This tank has two independent supply connections under float valve control from independent taps brought in from the street mains. The house supply is pumped to a 16 x 16 x 7-ft. open steel-plate tank in the attic, which supplies water directly to the top floors as far down as the nineteenth floor; the remainder of the building below this floor is divided into four sections, each of which is supplied through a Kieley water-pressure reducing valve for proper adjustment of the pressure at the lower levels, these valves being located at the fifteenth, eleventh, seventh and third floors.

The vacuum-cleaning equipment consists of an installation of two motor-driven vacuum pumps with dry and wet-dust separators complete, each pump being capable of operating the system to a capacity of sixteen of the 12-in. sweepers or renovators used, in operation at the same time. The renovator equipment consists of thirty-two carpet renovators and floor sweepers, each of the 12-in. size, twenty furniture brushers and four hundred small renovators each for brushing clothes and for cleaning hats, it being the purpose to provide these conveniences in each of the rented offices.

In connection with the machinery installation there has been installed also an oiling system for the collection and filtration of dirty oil that has been used. This filtered oil is then delivered to elevated tanks from which it flows by gravity to the machine bearings. A 3 x 3 x 4-ft. sheet-steel tank for gathering dirty oil is located in the sump pit. The oil drips are piped to this tank, and the oil is pumped from it to the filters by a Worthington motor-driven triplex pump. Two White Star duplex lubricating oil filters are installed in duplicate, each having a capacity of 100 gal. per day. A second triplex pump is provided to raise the filtered oil to the elevated storage tanks. From these tanks it is delivered to the machinery by a system of oil piping with Segrist special oiling cups at the outlets. The triplex pumps are cross connection so that either may be used for dirty or filtered oil, and the dirty oil tank is fitted with a high and low-level alarm to prevent emergencies.

Heating System.—The building is heated throughout by direct radiation, which is proportioned in the usual manner on the thermal unit basis of heat loss, and in which radiator units are given the usual locations under windows for counter-action of glass exposure. Bundy standard cast-iron radiators were used throughout, of which a total of over 57,000 sq. ft. of radiation has been installed. This radiation is supplied with exhaust steam at low pressure from the power plant, the condensation being returned by a pump-operated return system with the Paul vacuum system for the removal of air and vapor. Steam is supplied to the radiators by 56 riser lines which are distributed along the outer walls of the building for most convenient connections to the radiator units, the risers being themselves supplied with steam on the down-feed system from a series of distributing mains in the attic space. The distributing mains connect with the atmospheric riser from the exhaust steam headers in the cellar, at a point just below the back-pressure valve for relief to the atmosphere. The down-feed risers are valved at top and bottom and are run together with ¾-in. air lines in chases in the wall construction, the branch connections to radiators being made concealed under the floor level in trenches of galvanized iron filled with mineral wool.

A Large Turbine Runner.

The condensation from the radiation is gathered by a ring main connecting with the bases of the risers, which deliver to a pump governor in the feed pump room, so that any of the three feed pumps may be operated for automatic return of the condensation to the boilers. Live steam make-up is added to the exhaust supply, when necessary, from a 4-in. high-pressure steam line that is carried from the cellar to the attic, connecting there with the distributing main through two Kieley pressure-reducing valves, one a high-pressure and the other a low-pressure valve. The air lines consist of ¼-in. branches from the Marsh Paul air valves on the radiators to the ¾-in. vapor risers in the chaser beside the down-feed risers, while lines connect in the basement with a gathering system that leads to exhausting apparatus of the Paul system. All of the radiators throughout the building, excepting those in halls, toilet rooms and in the basement, are under automatic temperature control, for which the Johnson system of temperature regulation is used.

Ventilation is provided in this building only to a limited extent, being used only in the cellar space for the ventilation of the heated machinery sections. For this purpose two centrifugal blowers are installed in the cellar at the northerly end of the turbine room, one for fresh air supply and the other for ventilation, both of which units have 7-ft. wheels, 4 ft. in width, and were supplied by the American Blower Co., Detroit, Mich. They each have direct-connected motor drives, consisting in either case of 15-h.-p. Type S Westinghouse motors fitted for variable speed by field control from 135 to 200 r.p.m. The arrangement of duct connections from the blowers is for a general distribution of air in the cellar, the supply outlets and exhaust intakes being located in alternating positions on opposite sides of the rooms, as shown in the general cellar plan. The blowers have each a maximum capacity of 30,000 cu. ft. per minute. The ducts are all located on the cellar ceiling and are constructed of No. 20 galvanized iron, with a covering of ½-in. asbestos air-cell insulation protected by 8-oz. canvas. The fresh air intake and exhaust delivery connections from the blowers are both made by means of ducts in conveniently-arranged shafts to openings at the base of the court space at the second-story level. Very satisfactory results have been obtained from this ventilating system, both boiler and engine rooms being maintained at very comfortable temperatures even in hottest summer weather.

The architects for this building were Messrs. Clinton & Russell, New York. The present mechanical arrangement of the building was designed by Mr. A. E. Wells and Mr. J. Dougan, of the firm of Clinton & Russell, and Mr. David M. Hess, engineer of the United States Express Co., with Mr. Chas. R. Armstrong, New York, as consulting engineer. Mr. Hess is in present charge of the mechanical equipment.

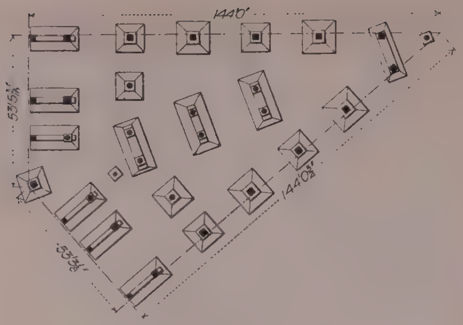
An Unusual Turbine.

A large low-head hydro-electric plant has recently been constructed at Wesermüklen, on the Weser River, not far from the city of Bremen. It will furnish current for lighting purposes and to operate flour mills and is noteworthy for the large dimensions of the water-wheels. These are Francis turbines of special design, with vertical shaft and single runner weighing over 33,000 lb. The general appearance of the runner is shown in the accompanying illustration, and some idea of its enormous size can be gained by comparing it with the men and boys grouped about it.

The blades are steel plates held securely by a cast-iron ring, which also divides the water in such a manner that, in spite of the very variable head under which the plant operates, the wheel is always able to furnish about the maximum computed output with high efficiency. The discharge of the runner working under 1 ft. head is about 335 cu. ft. per second. The large size of the runner made it necessary to ship it on a special car having two six-wheel trucks connected by a pair of heavy plate girders, between which the runner was suspended.

The wheels have been furnished by the Amme, Giesecke & Konegen Co., of Brunswick, Germany. This is a comparatively new company, which began business in 1896 with about 120 men and now has a payroll of over 2,500 men. The manager of its hydraulic turbine department is Mr. Viktor Gelpke, whose book on turbines was recently reviewed in this journal, and the chief engineer of the department is Mr. Guido E. Hemmeler, who has recently been visiting the United States.

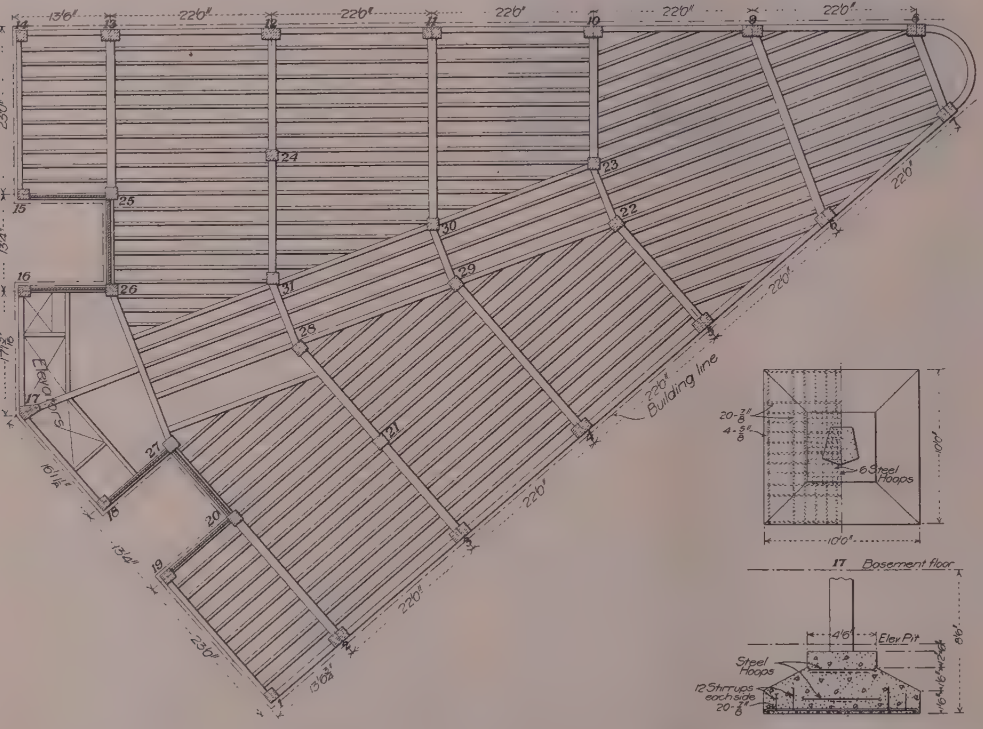
The Manufacture of Alcohol from Peat is reported to have been found successful and cheap at a number of points in Europe. A Danish company that has been operating two experimental plants, one in Denmark and the other in France, has found the cost of manufacturing to be about one-quarter of that from potatoes. The process consists in converting by means of sulphuric acid the cellulose of the peat into a soluble carbo-hydrate which is fermented by a special yeast.



FOUNDATION PLAN.

The First National Bank Building in Oakland, California.

Among the buildings erected in San Francisco and vicinity since the fire of two years ago is one recently completed for the First National Bank at Oakland. It occupies an approximately triangular area about 144 ft. long and nearly 100 ft. wide near the center of the business part of the town at the intersection of Broadway and San Pablo Sts., and has a basement, seven full stories and an attic, reaching to a total height of about 100 ft. above the curb. It is built entirely of reinforced concrete, in accordance with the revised building laws of San Francisco; allowance is made for a wind pressure of 30 lb. per square foot on all of the vertical surface and for live loads of 75 lb. per square foot on each floor and for column loads equal to the combined floor and wind stresses, the sum of the former being diminished as usual by successive increments of 5, 10 and 15 per cent, and so on from the top down. All columns were made from 1:2:4 concrete with Portland cement and 1-in. broken stone and are loaded to a maximum of 750 lb. per square inch in spiral-wound type and 450 lb. per square inch in hooped columns. In beams and girders the maximum compressive stress allowed was 500 lb., shearing 75 lb., and, in direct compression, a unit stress of 450 lb. per square inch was allowed; all beams and girders were reinforced with Kahn bars and all other reinforcement was made with plain round bars which were very liberally used in all columns. Owing to the wide floor spans, the column loads were heavy and the amount of steel in them in the basement story was large; the interior columns in the basement, mezzanine and first story were round or octagonal, and being spiral wound permitted the use of a high unit stress in the concrete, while the steel rods were limited to a stress of 10,500 lb. per square inch, corresponding to a ratio of fifteen for the modulus of elasticity. All other columns in the building are of rectangular cross section and are hooped, the rods in them being loaded only to a unit stress of 6,750 lb. per square inch. The limitation of the size of the columns materially increased the amount of reinforcement steel required for them.



Typical Floor Plan and Single Column Base.

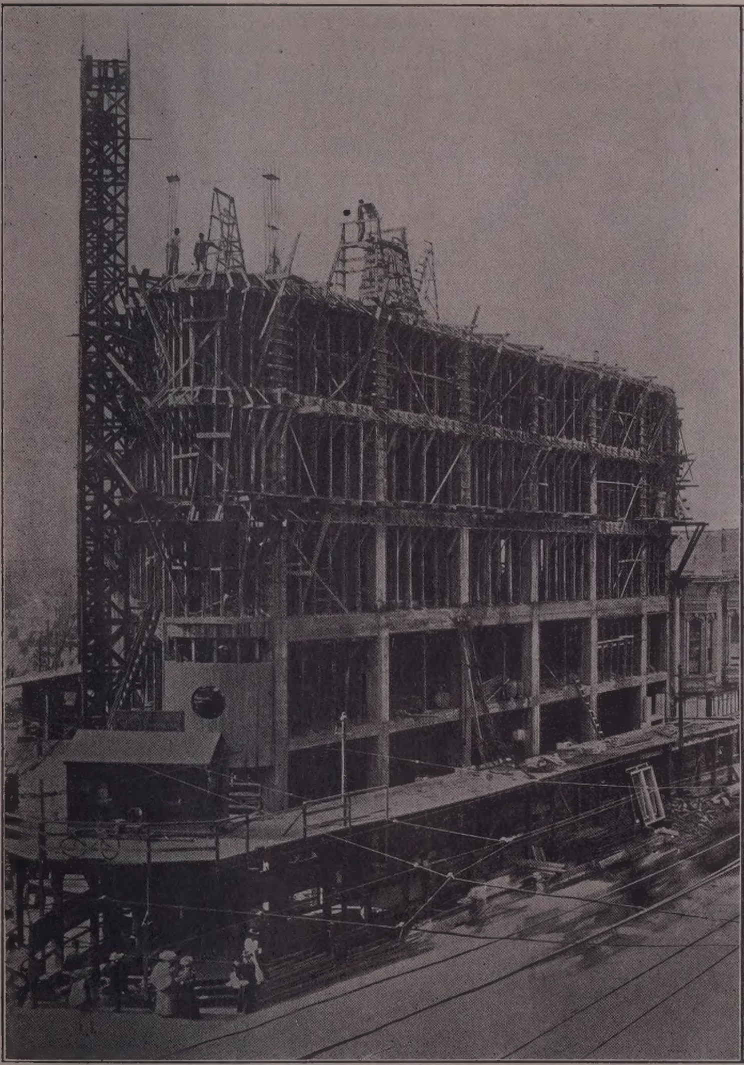
There are thirty-one main columns with reinforced-concrete footings proportioned to reduce the loads to about 4 tons per square foot on the fine dry sand about 16 ft. below the street level. All of the footings are rectangular, varying from about 10 ft. square to 11 x 20 ft. for pairs of interior columns. All of them are reinforced with two crossed tiers of round bars near the lower surface, with vertical stirrups around the edges and with two or four horizontal crossed tiers of hooped steel in the middle or upper part of the concrete. The long bars have short right-angle hooks bent at both ends and in the double column footings part of them are bent up to the upper part of the concrete to care for reverse stresses in the center.

The columns are spaced 22 ft. apart in the long walls of the building and are at different distances up to about 26 ft. in the opposite direction. The heaviest stresses are found in columns 4 and 11, which in the basement story are 3 ft. square. Each of the columns is reinforced with twenty bars 2 in. in diameter, and six bars 1½ in. in diameter, and is hooped every 6 in. vertically with a ¼-in. rod about 18 ft. long, bent and looped into a double rectangular form as indicated in the diagram, engaging the outside rods and keeping them accurately in position in the molds while the latter were filled with concrete. The heaviest octagonal columns were No. 6 and 9, each 3 ft. in diameter. These columns are reinforced with the same amount of steel as in columns 4 and 11, similarly arranged except that the outside bars are located approximately on the line of a circle formed by the hooping rods. In both cases the loops of the hooping bars are turned at an angle of 90 deg. with each other so as to provide equal reinforcement in both directions. At every floor the reinforcement rods for columns in the upper story are spliced to those for columns in the lower story by 12-in. lengths of pipes having a clearance of from 1/16 to ⅛ in. over the rod. Where the sizes of the columns change and the location of the rods in the different stories vary, the rods in one column are offset to correspond with those in the other column and permit the connection to be made.

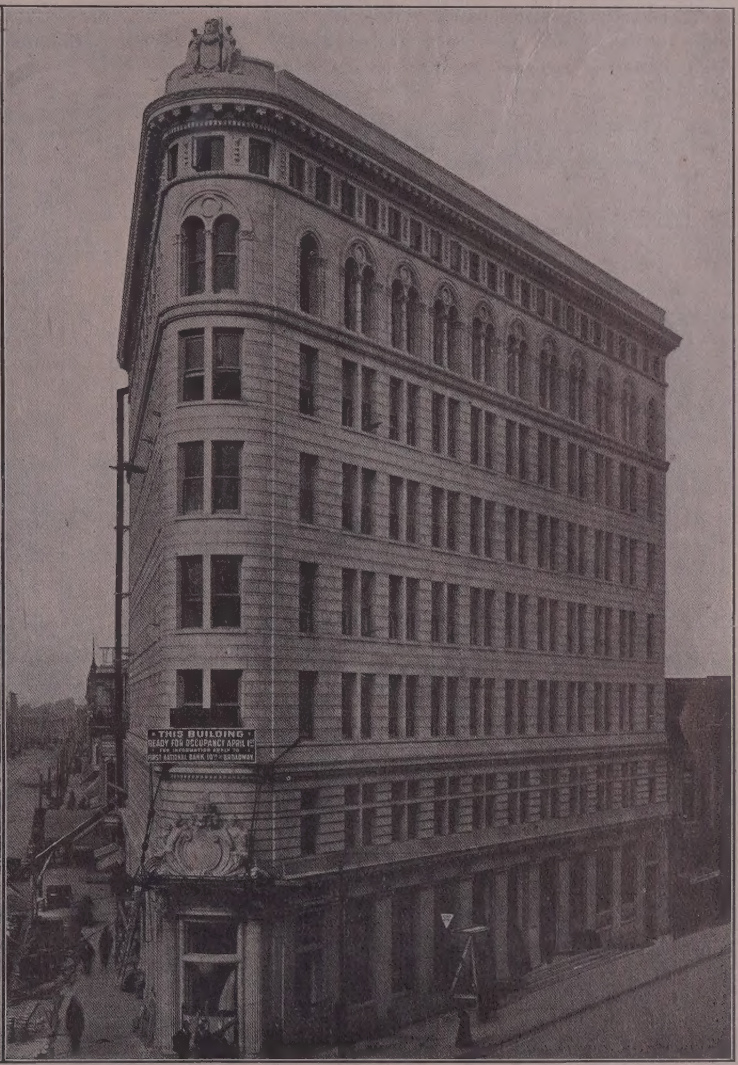
Forms for Floor Slab and Girders.

The general arrangement of beams and girders throughout the building is substantially like that shown for the typical floor, except for the first and second floors, where variations occur in the wide end of the building on account of differences due to the main stairway, vaults, light courts, and sidewalk floor. The continuous 3-in. floor slab is everywhere supported on longitudinal beams, 2 ft. deep, 5 in. wide and 2 ft. apart on centers, that are parallel to the main street front except in the center panel of the building where they bisect the angle of the street. These beams are supported by heavy transverse girders perpendicular to the street line, which have maximum dimensions about 27½ ft. long with a cross section of 18 x 24 in., exclusive of the floor slab. The floor is reinforced by ¼-in. rods, except in the irregular panels around the elevator shaft and stair-wells, where bars from ⅜ to ⅝ in. in diameter are spaced about 12 in. apart in one or both directions.

At the narrow end of the building the two converging building lines are connected by a tangent arc of a circle of small radius and the wall is carried by a correspondingly curved concrete girder 18 in. deep and 10 in. wide, which is knee-braced to columns 7 and 8. The construction here differs from that often adopted under similar circumstances in that the center of the curved girder is entirely free, and that the cantilever girder, often fulcrumed on a straight girder connecting the same two columns to support the center part of the curb girder, is here omitted.



A View during the Progress of Construction.


THIS BUILDING
READY FOR OCCUPANCY APRIL 1ST
FOR INFORMATION APPLY TO
FIRST NATIONAL BANK 10TH & BROADWAY

A View of the Building with Exterior Finished.

The first floor is extended 14 ft. and 18 ft. beyond the building lines to carry the sidewalks over the vaults on 8 x 14-in. girders supported at one end on the wall girders and at the other end carried by the retaining wall. Large areas between the girders are filled with vault lights and the remainder of the surface is covered with floor slabs up to about 8 ft. wide, which slabs are reinforced with crossed ¼-in. bars about 12 in. apart in both directions. Between columns 20 and 21, 12 and 13, the floor construction is special, on account of the curved double stairway up to the mezzanine floor and a two-story vault; a portion of the second floor is also special, due to a single curved stairway from the mezzanine floor, and because there are no air-shafts at this level. Above the latter the air-shafts appear and the construction is like that of the typical floors throughout. At two places in this floor hangers made with pairs of 4 x ½-in. vertical bars are provided to support the mezzanine floor. These hangers were built into the mold before the second-floor beams were cast; they were also located to pass between the reinforcement bars in the lower part of the beam and to engage with a special riveted loop the pair of long horizontal 1⅝-in. distributing bars embedded in the floor slab.

The mezzanine floor in the first story is accessible from the ground floor by means of a double curved stairway, and directly from the latter by a single stairway. It affords entrance to the second story of the vault, adjacent to the stairway, and provides a handsome curved balcony which is an architectural feature of the decorative scheme of the second story. The girders in it are special, being entirely different in arrangement from those of the other floors, as indicated in the floor diagram. Care is given to provide them with positive separation from the walls of the vault and they are generally supported directly from the columns, but at two points are suspended, as before mentioned, from the girders of the second floor. The curved balcony is in reality cantilevered from the front of the two columns 29 and 30, and from their adjacent main transverse girders, but the stresses in it are somewhat indeterminate on account of the combination of the projecting floor platform with a curved fascia that connects the lower ends of the suspension rods with an arc of over 100 deg. and acts to an indeterminate amount as a stiffening and bearing girder.

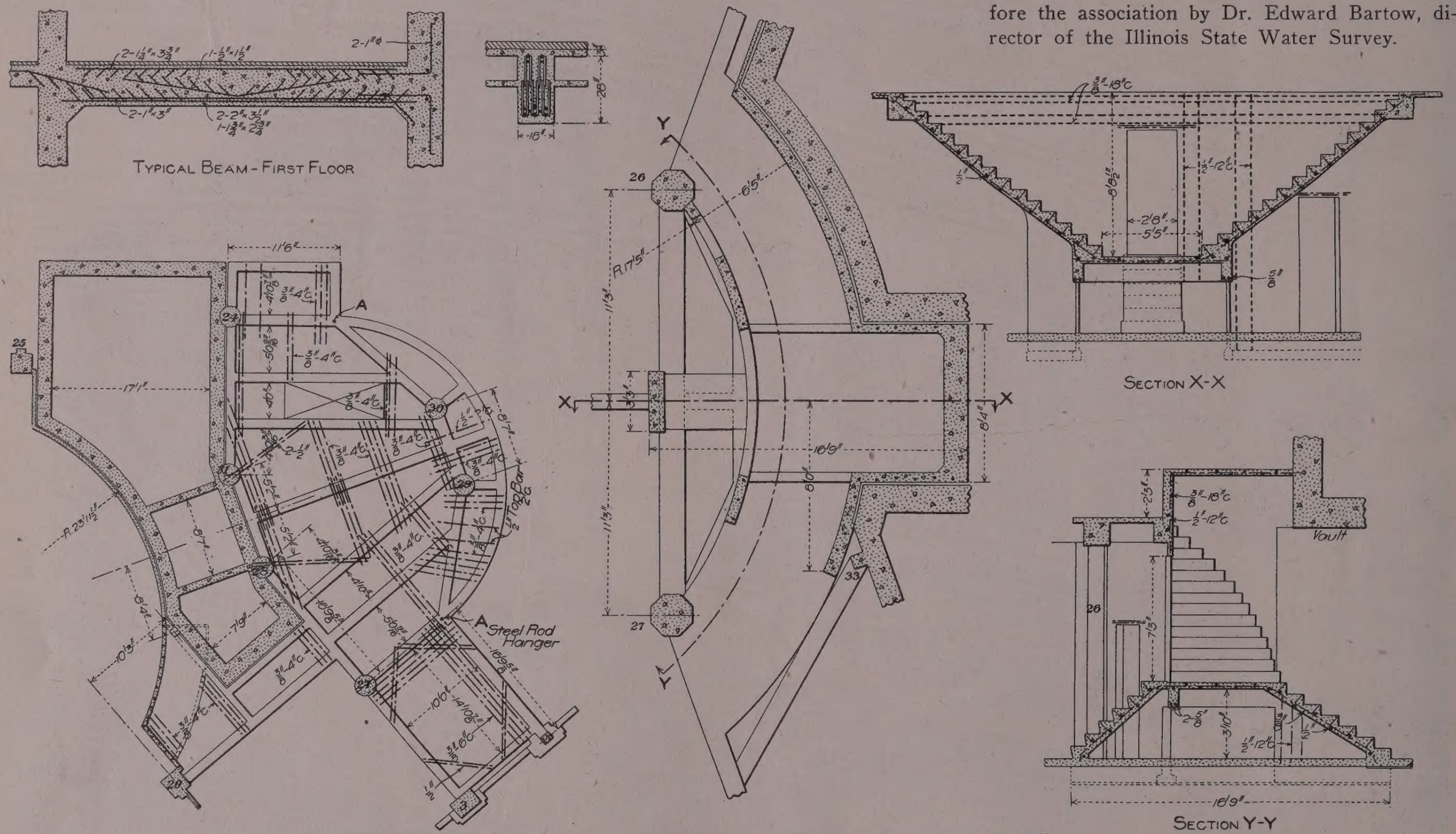
The construction of the roof is similar to that of the typical floors except that the girders are lighter, and several open skylight spaces are framed between them and that a concrete pent house about 10 ft. high is built on it with short vertical rectangular columns on the center line of main columns 16, 17, 18, 26 and 27. The exterior walls are carried up to a height of 19 in. above the highest part of the flat roof of the main building and are reinforced by four continuous lines of horizontal ½- and 5/16-in. rods above the cornice level. The cornice is of solid concrete construction of the simplest type and consists of three rectangular offsets, together projecting 15 in. beyond the face of the wall, with the upper line 3 ft. above the top of the window openings. Moldings are reinforced by four continuous horizontal lines of ⅜-in. round rods and by two 1 x 3-in. Kahn bars, all of them tied together by ⅜-in. transverse rods 3 ft. apart in vertical plane and anchored to the wall columns by U-shape bars in every panel point.

The vaults between the first and second floors have solid walls 18 in. thick, reinforced by horizontal ½-in. bars, 12 in. apart vertically, near the inner and outer faces, and with ½-in. vertical bars, 12 in. apart, in the plane of each set of horizontal bars. The 6-in. floor slab is reinforced by ½-in. longitudinal and transverse bars, 6 in. apart, and is supported by 12 x 14-in. beams 4 ft. apart, each of which is reinforced with six 1-in. round bars.

The main stairway from the first to the mezzanine floor is of a graceful design, with two curved flights meeting on a platform or landing about 4 ft. above the first floor, and together forming a segmental arc of about 90 deg. from column 26 to 27. The stairs are supported by the curved and straight walls and are made without string pieces, but have solid triangular steps connected at their intersections by a single continuous sheet of concrete forming the inclined lower surface of the stairway. Each step is reinforced by a single full-length ½-in. horizontal bar in the center and there are inclined ½-in. bars 7½ in. apart curved to correspond with the side walls.

The long first-floor girders connecting columns 4 and 29 are typical of the heaviest beams and girders in the building. Their reinforcement is indicated in the accompanying diagram, which shows five full-length horizontal Kahn bars in the lower part of the beam, two in reverse position in the upper part of the beam and one bent bar extending from the lower part of the beam in the center to the upper part at both ends. Besides these bars there are four 1-in. right-angle anchor bars with short bent ends connecting the girder to the wall and a bent Kahn bar interlocking with the main reinforcement bars at one end and connecting the girder in the adjacent girder in line beyond it. The knee-braces at the wall end are also reinforced by short inclined bars made from waste ends of any convenient size.

The site of the building was excavated by hand to a depth of about 12 ft. below the curb level, open rectangular pits were dug about 4 ft. deeper and forms were built in them for the single and double-column footings. Thin layers of concrete were spread in the bottoms of the forms, on the level surface of the earth, and on them the horizontal reinforcement bars were arranged as indicated in the progress photograph. The vertical shear rods were put in place and secured to light horizontal strips nailed across the upper edges of the forms. The latter were filled with concrete made in a Ransome mixing machine located at the street level and delivered through a chute to wheelbarrows distributed over wheeling planks placed in any part of the site. Three full sets of forms and molds were provided and after completing the first floor the building was erected at the rate of about a story per week.

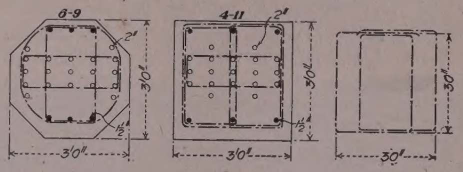


Mezzanine Floor Plan and Main Stairway of First National Bank Building.

The streets on both sides of the building were protected by heavy working platforms or decks over the sidewalk and the concrete was delivered to the floors where it was required by means of a hod hoist operated in a temporary outside wooden tower. The column molds were of very simple construction, built up with 1-in. dressed vertical boards secured by transverse cleats and thoroughly nailed together. After the columns had set these were removed, knocked to pieces, cut up and used over again as available.

The floor molds were of simple, although special construction and were particularly designed for uniformity, so as to be easily removed and used repeatedly. As nearly all of the beams have a uniform depth, spacing, and width, the bottoms of the molds were made with horizontal single boards supported on the column molds and on intermediate vertical shores. They were about 2 in. wider than the thickness of the beams and on each edge supported the lower edge of an inverted trough with the sides hinged to the middle part, the ends of the trough being invariably connected to the column or girder molds. The upper surfaces formed the supports for the beams and floor slabs, providing a solid platform and working surface as indicated in the detail photograph over which the concrete was distributed in wheelbarrows as required.

After the concrete was two days old, the troughs were collapsed and removed, leaving the thin floor slabs unsupported, but not interfering with the bottom pieces, which were left under the beams and girders for several days or weeks as seemed desirable. Special framing was required for the curb girders at the narrow end of the building and for the cornice, but all of the other molds were simple and regular and were easily and rapidly handled. After the completion of the columns and floors, the walls were built up to the second floor with ashlar masonry and above that of brick faced with terra cotta in large thin blocks pointed to resemble ashlar masonry and securely anchored to the brickwork.



Column Sections.

The building was commenced about the first of April, 1907, and was practically finished March 1, 1908. Its appearance is considered to be very satisfactory and attractive and it is said that since its completion the values of adjacent real estate have risen perceptibly, the increase being attributed largely to the construction of this building. The principal quantities involved in its construction include about 3,000 cu. yd. of concrete, made with Portland cement, terra cotta, manufactured by Atlantic Terra Cotta Co., 200 tons of round steel reinforcement bars and 150 tons of Kahn bars.

Mr. L. B. Dutton is the architect and the general contract was awarded to the Thompson-Starrett Co., Mr. Geo. Simpson, chief engineer.

Experience with Water Pipe Incrustation at Quincy, Ill.

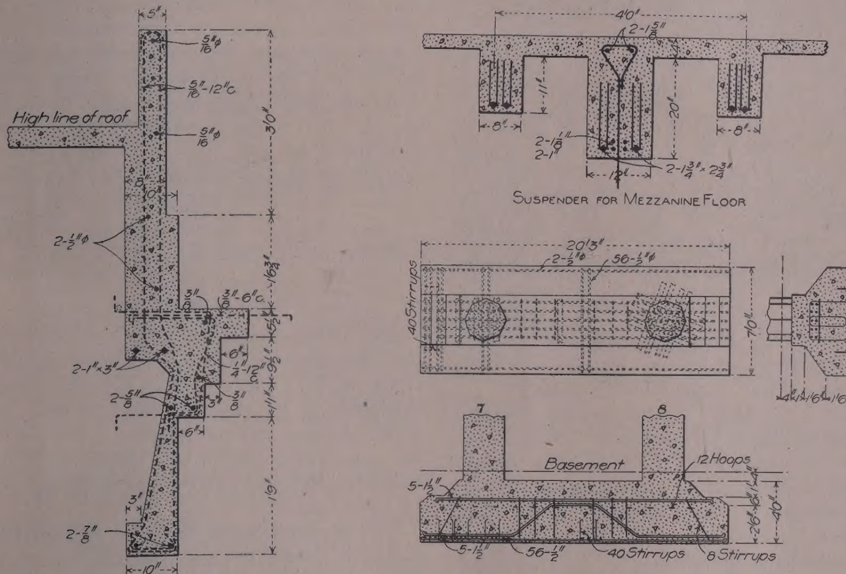
The incrustation of water-works pipes has been given no small amount of attention to determine means of removing the deposits and of preventing their recurrence. The operation of sedimentation and filtration systems using chemical coagulants has in several works introduced new conditions resulting in the deposition in pipes carrying water charged with the coagulants of hard incrustations which greatly reduce the carrying capacity of these pipes. Such an experience has occurred in the operation of the rapid-sand filtration plant of the Quincy, Illinois, water works system, and was described in a paper presented before the American Water Works Association by Mr. W. R. Gelston. The following notes have been prepared from that paper and from one giving a discussion of the chemical characteristics of the water and of the incrustation, also presented before the association by Dr. Edward Bartow, director of the Illinois State Water Survey.

The pumping station of these works is built on the bank of the Mississippi River from which the supply of water is secured. A Worthington horizontal triple expansion 12 x 19 and 30 x 24 x 24-in. pumping engine pumps the raw water from the intake well to the settling basin, which is located on the hillside about 450 ft. from the pump house and at an elevation of about 40 ft. above the pump. This basin is 70 ft. square and 10 ft. deep. Sulphate of iron and lime are used for coagulating purposes, the iron solution being drawn through the suction of the Worthington pump and the lime solution being pumped into the discharge pipe by a small auxiliary pump. The discharge from the lime pump was connected with the discharge from the large pump in a valve well just outside the pump house and here, Mr. Gelston says, appears a serious defect. This arrangement allowed a very thorough mixing of the two solutions with the raw water before they were finally discharged into the basin at a point 400 ft. away.

After a sedimentation period of about one hour in the settling basin, the water flows by gravity through a 20-in. cast-iron pipe to the filter house where the purification process is completed by fourteen Continental-Jewell filters. From the clear well under the filters the water flows back to the pump house and into the water chamber of a 5,000,000-gal. Gordon-Maxwell pump, which discharges it directly into the distribution system, the surplus passing into a reservoir of 18,000,000 gal. capacity. This reservoir holds easily a week's supply of water for the city and is located on a hill 230 ft. above the pump house and two and one-half miles away.

The beginning of the serious trouble precedes the date of Mr. Gelston's connection with the plant and this information was supplied to him by Mr. F. J. Brinkoetter, who is Chief Engineer of the pumping station.

During the summer of 1906 the Worthington pump began to show signs of distress. The pressure gage on this pump should show a head of water of about 47 ft. by actual levels, whereas the gage was indicating a rapidly increasing head. Investigation of the trouble led to the discovery of a thick deposit of scale on the inside of the 20-in. discharge pipe. Taps were made at several points along the line of pipe and it was found that the incrustation extended from the point of introduction of the lime solution to the discharge end of the pipe. Mr. Brinkoetter then appealed to Dr. Bartow to find out whether it might be possible to remove the deposit by the use of chemicals. Dr. Bartow went to Quincy and conducted a series of experiments to determine the action of various acids on the scale and the probable cost of removing it by acid treatment. It was decided that the cheapest and only certain method would be to cut it out with hammer and chisels. Finally, in November, 1906, the storage reservoir was filled and pumping discontinued while the discharge end of the pipe was being cleaned. At the time the pumps were stopped the pressure gage indicated a head of 100 ft. against which the pump was working.



Suspender for Mezzanine Floor

Cornice Section and Column Footings, First National Bank Building, Oakland.

The first 60 ft. of the pipe lies exposed in the settling basin and was cleaned without difficulty by melting out the middle joint which allowed three men to work at the same time. Outside the settling basin an excavation was made over every third or fourth joint of pipe which was removed by melting out the spigot end and cutting off the bell end with a diamond pointed chisel. After cleaning, the same pipe was replaced by using a 20-in. sleeve where the bell end was cut away.

A force of eight men worked one week and succeeded in cleaning about 150 ft. of the pipe. The deposit averaged about 5 in. in thickness and seemed to be about the same through the circumference of the pipe. It was then necessary to begin pumping again and the pressure gage showed a reduction of the head of water to 70 ft.

Nothing further was done until July, 1907, when the gages indicated a steam pressure of 100 lb. and a head of water of 91 ft., while the pump was running 19 r.p.m. Things began to look serious again, so it was decided to clean the remainder of the pipe. This end of the pipe was much more difficult to clean because it is crossed by one paved street containing a street-car track, and by four railroad tracks. A portion of the pipe also lies at a depth of 10 ft., which increased the amount of necessary excavation. The work was begun July 27, and was handled in the same manner as before. The pipe was all replaced and ready for use again August 4. A force of from 10 to 14 men was employed and the thickness of the scale increased from nothing, at the point where the lime solution was introduced, to 6 in. at the point where work was begun. At this time 250 ft. of pipe were cleaned, making a total of 400 ft., which were cleaned at a total expense of $420 for labor and new material used.

After this cleaning the steam gage stood at 61 lb. and the water gage at 47 ft. while the pump was making 22 r.p.m.

In order to obviate the necessity of ever cleaning all of this pipe again, the discharge pipe of the lime solution pump was extended about 300 ft. and made to discharge into the large pipe at a point just outside the wall of the settling basin. This allows a distance of 80 ft. in the large discharge pipe for the mixing of the two solutions before the final discharge into the basin. This 80 ft. of pipe will fill up again and require cleaning, but it will be a comparatively small job. This change in the point of introduction of the lime solution has undoubtedly lessened the efficiency of the basin and thrown more work on the filters. When the river is very turbid the old discharge opening for the lime pump is still used so as to obtain the best possible results from the basin.

Mr. C. R. Henderson, the former superintendent of the plant, stated that the present arrangement for handling the lime solution was installed early in 1902. As the lime is undoubtedly the active agent in the formation of the incrustation it would appear that this scale has been in process of formation only about 5 years, or at an average rate of over 1 in. per year.

During the past winter the gravity flow line leading from the basin to the filters has also become so filled up with the same deposit as to require cleaning. This line of 20-in. cast-iron pipe extends from the drop well in the basin, 115 ft. along the outside of the north wall of the filter house, then makes a one-quarter bend and runs 25 ft. along the west wall to a connection with a branch line from the Worthington pump discharge pipe. From this connection the pipe runs under the filter house through a sewer spillway. From this main supply pipe five 10-in. wrought-iron risers from 15 to 18 ft. in length extend just above the rims of the filter tanks. These risers are capped by tees from which three 6-in. wrought-iron branches supply one filter each. These 6-in. branches are, in turn, reduced to 4 in. and are controlled by butterfly valves.

The deposit in this filter pipe system finally became so serious that it became impossible to get enough water into the filter house to keep all the filters in operation, and the speed of the pumps had to be reduced about 2 r.p.m.

In February, 1908, pumping was discontinued for one week in order to clean a portion of the main supply pipe under the filter house, all of the five risers and the fourteen filter branch pipes. This work was done by disconnecting every joint and chiseling out the deposit, resulting in numerous difficulties. The fourteen branch pipes are of wrought-iron connected with screwed joints. These joints could not be disconnected until the thick incrustation on the inside was broken either by an excessive strain on the wrenches or by hammering. Had these joints been made up with flanged unions, Mr. Gelston said, the labor would have been much reduced. The five 10-in. risers are each in one piece. Their extreme length and great weight when half filled with solid rock together with the cramped quarters in which they had to be handled, made them almost impossible. They would be better in two sections connected with a flanged union.

The deposit had reduced the inside diameter of the 10-in. risers to about 6 in. The 4-in. sections just above the butterfly valves were some of them reduced to 2 in. The work was done by a force of six men in six days and the cost of labor alone amounted to $65. This cleaning resulted in an increase in the filtering capacity of the plant of about 30,000 gal. per hour. The 20-in. supply pipe, Mr. Gelston stated, will also soon have to be cleaned.

The experience at Quincy Mr. Gelston considers to emphasize the fact that solutions of iron and lime should not be forced together through long lines of pipe. If it is necessary to carry them in the same system, he says, the piping should be so arranged as to be conveniently taken apart for cleaning.

Table 1.—Analysis of the Incrustation.

Determination Made.	Per Cent.
Moisture	0.13
Loss on ignition less moisture	44.31
Silicious Matter	0.30
Silica SiO_2 0.15 per cent.	
Oxides of Iron and Alumina $Fe_2O_3 + Al_2O_3$	0.86
Calcium Oxide CaO	53.54
Calcium Ca 38.27	
Magnesium Oxide MgO	0.13
Magnesium Mg 0.08	
Sulphur trioxide SO_3	0.33
Sulphate SO_4 0.39	
Sodium Oxide Na_2O	0.16
Sodium Na 0.12	
	99.76

Hypothetical Combinations.	Per Cent.
Sodium Sulphate Na_2SO_4	0.37
Magnesium Sulphate $MgSO_4$	0.17
Magnesium Carbonate $MgCO_3$	0.17
Calcium Carbonate $CaCO_3$	95.53
Oxides of Iron and Alumina $Fe_2O_3 + Al_2O_3$	0.86
Silicious Matter	0.30
Moisture	0.13
Loss on ignition less water + CO_2	
Organic Matter	2.23
	99.76

Dr. Bartow concluded from experiments that although the incrustation could be removed with acid, the expense of such treatment was prohibitive. To account for the character and composition of the scale Dr. Bartow considered the original composition of the river water, the chemicals used in the treatment and the manner in which reactions take place between the various substances.

The average composition of the mineral content of the water from the Mississippi River at Quincy, for the year ending July 31, 1907, has been determined in the laboratory of the State

Water Survey. Samples were collected daily at the intake well of the Quincy pumping station These samples were combined to cover three periods per month, or thirty-six composite samples during the year. The average of these results Dr. Bartow holds to give a good idea of the general character of the Mississippi River at Quincy.

The composite analyses show the widest limits in the turbidity and suspended matter, and individual samples would undoubtedly show greater extremes than the composites. The variations in the soluble matter are considerable but not so great. As the analysis of the incrustation is of a cross section, only the average of the analyses of the water was given.

Table 2.—Average of 36 Composite Analyses of the Mineral Content of the Mississippi River Water at Quincy.

Constituents.	Parts per Million.
Turbidity	176.
Suspended matter	116.
Dissolved solids	203.
Alkalies Na	12.
Magnesium Mg	16.
Calcium Ca	36.
Iron Fe	0.46
Nitrate NO_3	2.2
Chlorine Cl	4.5
Sulphate SO_4	27.
Bicarbonates HCO_3	175.
Silica SiO_2	36.

Hypothetical Combinations.	Parts per Million.	Grains per Gallon.
Sodium Nitrate $NaNO_3$	3.0	0.17
Sodium Chloride NaCl	7.4	0.43
Sodium Sulphate Na_2SO_4	25.6	1.49
Mag. Sulphate $MgSO_4$	12.2	0.71
Mag. Carbonate $MgCO_3$	46.7	2.72
Calcium Carbonate $CaCO_3$	89.9	5.24
Iron Carbonate $FeCO_3$	1.0	0.06
Silica SiO_2	18.0	1.05
Total Mineral Matter	203.8	11.87

With regard to the chemicals used, the records of the water company show that during the year 1907, the minimum amount of sulphate of iron per million gallons was 195.5 lb., the maximum amount was 367.4 lb., and the average was 286.37 lb. The minimum amount of lime per million gallons was 295.2 lb., the maximum was 452.37 lb., and the average was 395 lb.

Since each pound of sulphate of iron requires 0.2 lb. of lime, there will be left 338 lb. per million gallons to treat with the bicarbonates in softening the water. This is more than enough to unite with the calcium bicarbonate and some magnesium to be removed is to be expected. That such is the case has been shown in two comparative analyses of water before and after filtration.

That the reaction between the lime and the calcium bicarbonate occurs first in shown by the very small amount of magnesium in the incrustation. The great difference in the composition of the incrustation and the residue is shown by the accompanying Table 3.

Tarle 3.—Comparison of the Percentage Composition of the Incrustation and the Mineral Content of the Mississippi River Water.

	Incrustation. Per Cent.	Mississippi River. Per Cent.
Sodium Nitrate $NaNO_3$	—	1.5
Sodium Chloride NaCl	—	3.6
Sodium Sulphate Na_2SO_4	0.37	12.6
Magnesium Sulphate $MgSO_4$	0.17	6.0
Magnesium Carbonate $MgCO_3$	0.10	22.9
Calcium Carbonate $CaCO_3$	95.53	44.1
Oxide of Iron and Alumina $Fe_2O_3+Al_2O_3$	0.86	—
Iron Carbonate $FeCO_3$	—	0.5
Silica SiO_2	0.15	8.8
Bases	0.15	—
Moisture	0.13	—
Organic Matter	2.35	—
Total	99.81	100.00

In explaining this comparison Dr. Bartow said the preponderance of the calcium carbonate over the other crystalline salts is explained by the insolubility of its crystals and the greater solubility of the other crystalline salts, namely: sodium sulphate and magnesium sulphate. These substances, therefore, remain in solution. The preponderance over the non-crystalline substances namely: the iron hydrate, formed by the iron sulphate and lime and the hydrates of aluminium and magnesium and the silica, is because the rapidity of the flow prevents these substances from becoming enveloped by the crystals of the carbonate. The small amount of magnesium carbonate is because the lime reacts, first with the calcium salts, and the magnesium is not precipitated till the calcium is used up.

The Action of Septic Sewage on Concrete.

The action of septic sewage on concrete has been considered little, if at all, in the design of most of the septic tanks that have been built in this country, although some recent experiences in this connection indicate that such action may produce serious results. Mr. W. S. MacHarg, of Chicago, when directing an excavation along one wall of a concrete septic tank, which had been in service between four and five years, found the concrete in that wall to be in such a badly weakened condition that the wall was collapsed by the pressure of the contents of the tank when the backfill against it had been removed. The concrete was well made with good cement when the tank was built and had shown no previous indications of deterioration. Mr. W. S. Shields, also of Chicago, under whose direction the tank was constructed, found recently that the concrete in two other septic tanks built under his supervision about five years ago in the South has evidenced recently very serious injury, which can scarcely be attributed to any other cause than the effects of the products of the action which occurs in the tanks. The upper 5 ft. of the walls of one of these tanks are above the ground level, and were perfectly tight during the first three years following the completion of the tank. About that time seepage through these walls began, and Mr. Shields found several considerable leaks through the concrete on a recent visit to the tank. The surface of the concrete bottom of a second tank in the same city, when that tank was recently cleaned, was also found to be loosened so it could be shoveled out like so much broken stone.

The two latter tanks receive straight domestic sewage containing no trade wastes. The first tank mentioned was built to treat the domestic sewage of a large manufacturing establishment, and receives practically no trade wastes from the shops of this establishment. Neither Mr. MacHarg nor Mr. Shields have undertaken to determine certainly whether the concrete in these three cases has been impaired by the action of the septic sewage, as it appears to have been. Both of them are, however, sufficiently convinced that some such action may be expected that they contemplate further investigations of concrete in other tanks, and in outfall sewers that have been in service long enough to show any results from the action of the septic sewage that may occur. While it is conjectural to state that septic sewage may seriously effect concrete, even though not for some years after the completion of a structure, detailed studies of this phase of the maintenance of sewage works will be fully justified. Should any detrimental results be shown to be caused by such action it may be necessary to use some other materials for structures subjected to the action, or some method of protecting the concrete from contact with the septic sewage.

Letters to the Editor.

Hydraulic Sluicing.

Sir: The description of the plant and methods used in handling the heavy grading work on the coast extension of the Chicago, Milwaukee & St. Paul R.R., as printed in your issue of May 2, contains several features of design which have probably not been considered to any extent by most of those reading of them. Aside from the novelty of the general scheme of adapting hydraulic methods to work of this character, the most noticeable of these features is the design of the wood-stave pipe line used to deliver water from the end of the flume to the pumping plant. According to the description, this pipe is operating under a maximum head of 400 ft., stated to be the highest head, with one exception, for which pipe of this kind has been used. This exception is doubtless a hydro-electric development in eastern Oregon, where, I understand, a wood-stave pipe under a maximum head of about 420 ft. has given satisfactory results in service for some time. The use of wood-stave pipe under such very high heads is quite remarkable in the light of all that has been printed regarding the safe and economical limit for it to be in the neighborhood of 250 to 275 ft. At the same time, this pipe was in both cases built where practically perfect lumber was available for staves, while such lumber has not been readily obtainable at a reasonable figure in this vicinity for several years, although the present status of the lumber market in the Northwest may have altered conditions temporarily.

Another feature of the plant used in this work is the V-shaped timber flume. If this type of construction has so many evident advantages over the usual rectangular section as mentioned in your article, and it doubtless has, it seems strange such construction is not more frequently adopted. The one principal fact concerning this structure is that it could be made tight easily, although from the construction such a result might be expected. It is to be regretted, however, that your correspondent did not state definitely what amount of leakage from the flume had occurred.

Very truly yours,

W. S. P.

Denver, Colo., May 8.

Septic Process Patents Sustained.

Sir: After five years of litigation, ending in the Supreme Court of the United States, the claims of the Cameron Septic Tank Co. have been sustained in its suit against Saratoga Springs et al.; existing Sewage Disposal Plants involving the unlicensed use of the Septic Process are therefore declared to be infringements of the Cameron patents.

The Cameron Septic Tank Co. has enjoyed exceptional advantages for studying the subject of Sewage Disposal. It introduced the septic process into this country and has installed over 50 plants in the United States and Canada; its experience in the treatment of sewage of all kinds, under varying conditions, has therefore been extensive and covers a wide range. Municipalities and others contemplating the installation of sewage disposal plants are invited to avail themselves of this experience.

The Cameron Septic Tank Co., desiring to comply with the wishes of its many clients, offer the following alternatives:

1. To design sewage disposal plants and take contracts for complete construction.
2. To furnish plans and specifications, and license the use of plants constructed thereunder.
3. To license the construction and use of plants designed by other engineers.

Before the validity of the Cameron patents had been established by the courts, the Cameron Septic Tank Co. refrained from any interference with the operation of unlicensed plants, but now that these patents have been so completely sustained by the recent action of the Supreme Court of the United States, the same respect and consideration will be expected for them as has been accorded by the highest courts. An invitation is therefore extended to municipalities and others owning infringing plants, to communicate with the Cameron Septic Tank Co. for the purpose of effecting settlements, which may be secured on very reasonable terms provided useless litigation is avoided.

Very truly yours,

Cameron Septic Tank Co.

Chicago, Ill., May 8.